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MARCH 1983

# PRACTICES FOR PROTECTING AND ENHANCING FISH AND WILDLIFE ON COAL SURFACE-MINED LAND IN CENTRAL AND SOUTHERN APPALACHIA

Fish and Wildlife Service

In cooperation with
Bureau of Mines

U.S. Department of the Interior

There are five manuals in this series:

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in Central and Southern Appalachia. FWS/OBS-83/08.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Green River-Ham's Fork region. FWS/OBS-83/09.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Powder River-Fort Union region. FWS/OBS-83/10.

Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Southcentral U.S. FWS/OBS-83/11.

Practices for protecting and enhancing fish and wildlife on coal mined land in the Uinta-Southwestern Utah region. FWS/OBS-83/12.

FWS/OBS-83/08
March 1983

# PRACTICES FOR PROTECTING AND ENHANCING FISH AND WILDLIFE ON COAL SURFACE-MINED LAND IN CENTRAL AND SOUTHERN APPALACHIA

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FWS 14-16-0009-80-075

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U.S. Department of the Interior
Washington, DC 20240

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This report should be cited as:

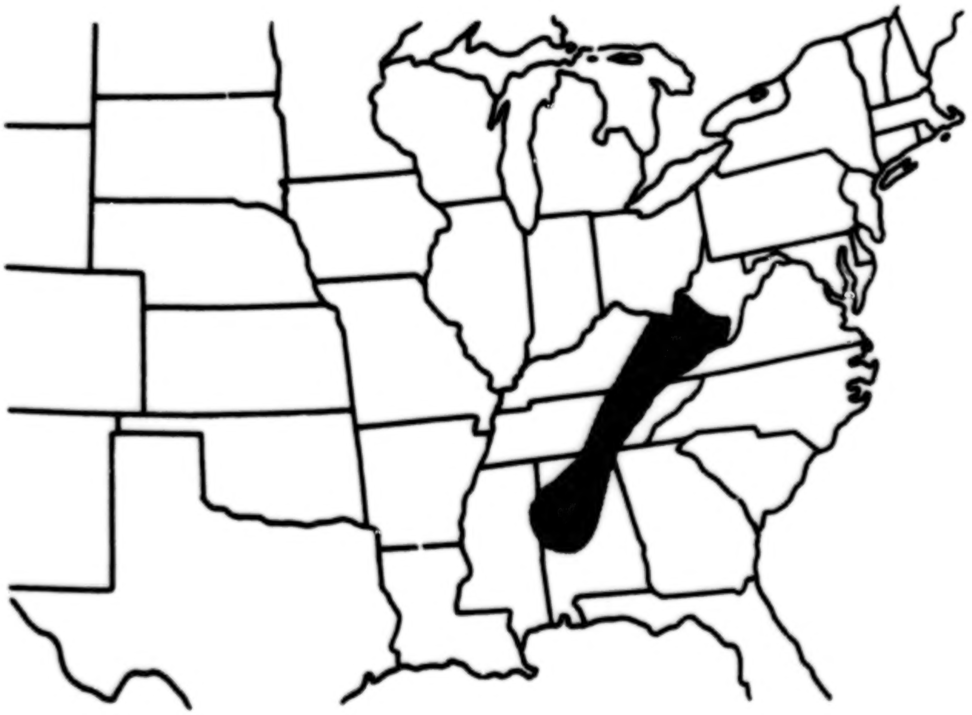
Ambrose, R. E., C. R. Hinkle, and C. R. Wenzel. 1983. Practices for protecting and enhancing fish and wildlife on coal surface-mined land in central and southern Appalachia. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-83/08. 208 pp.

# PREFACE

This handbook contains information on the "Best Current Practices" to protect and enhance fish and wildlife resources on surface-mined land in central and southern Appalachia. Current State and Federal legislation was reviewed to determine those practices which were most compatible with the performance standards related to Best Technology Currently Available, Fish and Wildlife Plans, and Reclamation Plans. The information presented in the handbook is region specific, mentioning the risks and limitations, the approximate cost, and the maintenance and management requirements of each practice. Reclamation plans are also included, which integrate the best current practices with the restoration of specific habitats in the region.

This work was supported by funding from the U.S. Bureau of Mines, Minerals Environmental Technology Program. The Chief Project Officer was Tom Brady, Spokane Research Center.

The geographical area included in this handbook (Central and Southern Appalachia) is illustrated by the map below.



## CONTENTS

Page

PREFACE iii
FIGURES vii
TABLES x

1. INTRODUCTION 1
   1.1 Use of the Handbook 1
   1.2 Factors Affecting Protection and Enhancement Practices 3
2. PLANNING 4
   2.1 Fish and Wildlife Needs 4
      2.1.1 Bobwhite Quail 4
      2.1.2 Cottontail Rabbit 4
      2.1.3 Ruffed Grouse 5
      2.1.4 White-tailed Deer 5
      2.1.5 Mourning Doves 5
      2.1.6 Wild Turkey 6
      2.1.7 Small Furbearers 6
      2.1.8 Nongame Birds 6
      2.1.9 Threatened and Endangered Species 7
   2.2 Management for Fish and Wildlife 7
3. BEST CURRENT FISH AND WILDLIFE ENHANCEMENT AND PROTECTION PRACTICES 9
   3.1 Preliminary Practices Used to Enhance and/or Protect Fish and Wildlife Resources 9
      3.1.1 Roads 9
      3.1.2 Powerlines 13
      3.1.3 Stream Crossings 15
      3.1.4 Fences 23
   3.2 Practices Used During Mining to Enhance and/or Protect Fish and Wildlife Resources 30
      3.2.1 Overburden and Soil Handling 30
         a. General Procedures 30
         b. Selective Placement and Stabilization of Spoils and Topsoils 31
         c. Mycorrhizae and Seed Inoculum 35
      3.2.2 Maintenance and Supplement to Food, Water, and Cover Resources 39
         a. Buffer Zones 39
         b. Use of Slash from Clearing and Grubbing 42
         c. Rights-of-Way Management 47

CONTENTS (continued)

Page

3.2.3 Protection of Fish and Wildlife Resources During Mining ... 51
a. Wildfire Control ... 51
b. Pesticide and Herbicide Use ... 54
c. Drilled Holes ... 56
d. Dust Control ... 59
e. Sediment Ponds ... 62
f. Diversion Ditches ... 66
g. Access Control ... 70
3.3 Practices or Reclamation Techniques Used to Enhance and/or Protect Fish and Wildlife Resources ... 72
3.3.1 Revegetation ... 72
a. Seedbed Preparation ... 72
b. Mulching ... 77
c. Direct Seeding of Trees and Shrubs ... 80
d. Planting of Tree and Shrub Seedlings ... 83
e. Vegetation Clump Transplanting System ... 86
f. Nurse Crops and Preparatory Crops ... 90
g. Stabilization of Critical Areas with Fabric Netting ... 93
h. Food Patches ... 96
i. Planting Patterns ... 99
j. Use of Native Species and Species Suitable to Wildlife ... 107
k. Grazing Management ... 112
3.3.2 Water Resources Improvement and Development ... 115
a. Stream Improvements: Mitigation and Restoration Techniques ... 115
b. Streambank Protection ... 125
c. Final Cut Lakes as Permanent Impoundments ... 132
d. Fish Stocking ... 133
e. Pond Fertilization for Fish Management ... 140
f. Fish Shelters in Ponds and Lakes ... 143
g. Creation of Impoundments for Waterfowl ... 149
h. Island Development for Waterfowl ... 154
3.3.3 Other Habitat Improvements ... 158
a. Creation of Topographic Features for Maximum Habitat Diversity ... 158
b. Brushpiles ... 161
c. Rock Piles ... 164
d. Nest Structures ... 167
4. REGIONAL RECLAMATION PLANNING ... 172
4.1 Introduction ... 172
4.2 Example Reclamation Plan ... 173
4.2.1 Site Preparation ... 177
a. Grading and Shaping ... 177
4.2.2 Reclamation Plantings ... 180
a. Revegetation ... 180
b. Maintenance ... 180

## CONTENTS (concluded)

Page

4.2.3 Additional Enhancement for Wildlife ........................ 183
  a. Sediment pond retention ........................ 183
  b. Brushpiles ........................ 183
  c. Nest boxes ........................ 183
  d. Access restriction ........................ 183

APPENDIXES

A. Consultation and Coordination Directory ........................ A-1
B. List of Species Referenced in the Text ........................ B-1
  B.1 List of Plant Species ........................ B-2
  B.2 List of Animal Species ........................ B-4
C. List of Plant Species and Their Uses for Wildlife in the Central and Southern Appalachian Region ........................ C-1

# FIGURES

| Number | | Page |
|---|---|---|
| 3.1-1 | Sight distance on vertical curves | 11 |
| 3.1-2 | Sight distance on horizontal curves | 11 |
| 3.1-3 | Cross sections of metal culverts | 17 |
| 3.1-4 | The arch bridge, like an arch culvert, provides for fish passage | 17 |
| 3.1-5 | Baffle placement in a metal culvert | 18 |
| 3.1-6 | The use of low-head dams to raise the water level to culvert level | 18 |
| 3.1-7 | Multiple or stacked culverts used to compensate for water flow fluctuations | 20 |
| 3.1-8 | Diagonal view of slanting deer fence showing guy wire support construction | 24 |
| 3.1-9 | Diagonal view of slanting deer fence showing wooden diagonal post construction | 24 |
| 3.2-1 | Vegetative buffer zones used to protect stream water quality | 39 |
| 3.2-2 | A well constructed sediment pond in the Appalachians | 63 |
| 3.2-3 | Effective cross-section shapes for diversion ditches | 67 |
| 3.2-4 | Stone center diversion for use in areas with heavy runoff | 68 |
| 3.3-1 | Installation of fabric netting for stabilization of critical areas | 94 |
| 3.3-2 | K-dams | 117 |
| 3.3-3 | K-dams and board dams | 118 |

FIGURES (continued)

Number Page

3.3-4 Cross section of log dam ..... 121

3.3-5 Rock dams ..... 122

3.3-6 Current deflectors ..... 123

3.3-7 Stream cross section showing the use of gabion mats on a sloping streambank ..... 126

3.3-8 Placement of stone gabions to protect a streambank ..... 127

3.3-9 Examples of the use of a combination of gabion deflectors ..... 128

3.3-10 A diagram demonstrating the use of log cribbing for streambank protection ..... 129

3.3-11 Use of riprap to protect a streambank from erosion ..... 130

3.3-12 Trout ponds may be successful in the shaded area ..... 133

3.3-13 Simple, effective types of fish shelters ..... 144

3.3-14 Brush shelter under construction ..... 145

3.3-15 A large tire shelter ..... 146

3.3-16 Catfish spawning shelters ..... 146

3.3-17 Placement of fish shelters in a pond ..... 147

3.3-18 A seasonal pond of the type suitable for attracting wood ducks and other waterfowl ..... 150

3.3-19 Sowing Japanese millet on an exposed moist mud flat immediately after drawdown ..... 151

3.3-20 Aerial view of an island created for waterfowl on a surface mine reservoir ..... 154

3.3-21 Schematic showing (A) possible areas of earth removal and (B) areas of placement to create post-impoundment islands ..... 155

3.3-22 Earthen-mound islands can easily be constructed with a bulldozer during impoundment construction ..... 156

3.3-23 Contouring to create wildlife habitat ..... 159

## FIGURES (concluded)

| Number | | Page |
|---|---|---|
| 3.3-24 | Windbreak effect of land contouring | 159 |
| 3.3-25 | Construction of brushpile shelters demonstrating base construction methods (A-logs, B-boulders, C-log/boulder combination), dead brush construction (D-F), and living brush construction utilizing conifers (G) or hardwoods (H) | 162 |
| 3.3-26 | Rock piles are ideal shelters for small wildlife | 165 |
| 3.3-27 | Eastern bluebird box | 169 |
| 3.3-28 | Wood duck nest box | 169 |
| 3.3-29 | Examples of bird nest structures | 169 |
| 4.2-1 | Topographic map showing the contour of the Frost Bottom Mine site area | 174 |
| 4.2-2 | Vegetation types on the Frost Bottom Mine site | 175 |
| 4.2-3 | Soils on the Frost Bottom Mine site | 176 |
| 4.2-4 | Recontoured topography of the Frost Bottom Mine site and adjacent areas | 178 |
| 4.2-5 | Recontouring scheme for the terraced areas of the Frost Bottom Mine | 179 |
| 4.2-6 | Recontouring scheme for the non-terraced areas of the Frost Bottom Mine | 179 |
| 4.2-7 | Revegetation scheme of the Frost Bottom Mine site | 181 |

## TABLES

Number Page

3.1-1 Specifications and costs for a slanting deer fence with wooden supports ........ 27

3.1-2 Specifications and costs for a slanting deer fence with wire supports ........ 28

3.2-1 Suggested quick-cover species for spoil pile stabilization in the central and southern Appalachian Region ........ 33

3.3-1 Pure live seed seeding rates for selected woody species ........ 81

3.3-2 Seedlings per 0.4 hectare at various spacing distances ........ 84

3.3-3 Food patch mixtures for planting in spring for the eastern United States ........ 97

3.3-4 Nest box dimensions and placement height for selected species of birds ........ 168

4.2-1 Plantings proposed for the Frost Bottom mine site ........ 182

# 1. INTRODUCTION

Numerous techniques and methods are being used during surface mine and reclamation operations throughout the country to minimize disturbances and adverse impacts to fish and wildlife. Some of these methods are accepted or recognized as state-of-the-art technology, whereas others may be outdated or even detrimental. This handbook is being written as a "first approximation" to gather design specifications, to document effective field techniques being used, and to highlight sources of information for techniques that are now in use. This review will also consider equipment, devices, systems, and methods that have proved useful in special cases. At a later date, and as more information becomes available, this handbook will be revised and updated to reflect the best current practices state-of-the-art.

To facilitate the transfer of information, the term "Best Current Practices" (BCP) has been used to present the field techniques that have been successful, or that show definite promise of being successful, on surface-mined land. The Surface Mining Control and Reclamation Act of 1977 states that "to the extent possible using the best technology currently available (BTCA), [the operator is required to] minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values, and achieve enhancement of such resources where practicable" (Section 515 [b] [24]). Furthermore, the Surface Coal Mining and Reclamation Operations Permanent Regulatory Program states that "within the constraints of the permanent program, the regulatory authority shall have the discretion to determine the best technology currently available (BTCA) on a case-by-case basis" (Section 701.5). The BCP's presented in this handbook are being offered as guidelines to the mining community and regulatory agencies for use not only when an environmental problem arises, but also when an operator wishes to initiate a wildlife management program.

IN ALL CASES, THE BCP's IN THIS HANDBOOK WHICH ARE SELECTED FOR USE ON A PARTICULAR SITE MUST BE APPROVED FOR USE BY THE STATE REGULATORY AUTHORITY. IN SOME INSTANCES, A BCP MAY NOT CONFORM TO THE LATEST STATE REGULATORY PROGRAM.

## 1.1 USE OF THE HANDBOOK

This handbook is one of several guides being developed by the U.S. Fish and Wildlife Service to aid mid-level managers, field inspectors, and mine reclamation specialists in the coal regions. Its purpose is to identify methods by which fish and wildlife resources can be protected and enhanced during the various phases of mine development and reclamation on a regional basis. Some of the techniques and practices are applicable to more than one geographic region, whereas others are very region-specific in their usefulness.

The handbook has been arranged to first present a section on the planning needs for fish and wildlife resources during the mining process. Regional problems are identified and the specific needs that individual sites would have are highlighted. Planning needs which are discussed include gathering of baseline data, the evaluation of site potential, preparation of a fish and wildlife plan, and reclamation planning.

BCP's for protection and enhancement of fish and wildlife resources are presented. The format for each BCP generally follows the topical outline below:

Purpose: The usefulness of each BCP is explained, giving its geographic and habitat applicability.

Development: The steps for implementing each BCP are given, emphasizing the BCP's relationship to postmining land uses and compatibility with other BCP's.

Maintenance and Management: Considerations for the long-term upkeep of some BCP's are stressed.

Labor and Materials: To give some idea of the cost of implementing a BCP, levels of effort are given in terms of man-hours, types of personnel, and dollar values (where costs could be estimated). Equipment and construction materials are also itemized.

Sources of Information: For further assistance, the following information has been provided where it was available: the company or agency who used or proposed the BCP; government contacts; and useful literature, such as books, articles, publications, and studies.

Finally, several reclamation alternatives are given for specific habitats in the central and southern Appalachians. For a typical site within a habitat, appropriate BCP's are presented which are compatible with the terrain and indigenous fish and wildlife resources. These reclamation alternatives are designed to be used as an example of what could be done for fish and wildlife under a certain set of environmental conditions in the region. As a guide, they can offer ideas and suggestions to aid an operator with his site-specific reclamation plan.

The BCP's described in this handbook were chosen because of their applicability to the Central and Southern Appalachian Coal Regions. Considerations in their choice included the habitats to be reclaimed, major fish and wildlife species in the area, the postmining land use, and the objectives of the reclamation plan.

With the above considerations in mind, the BCP's are somewhat regionally specific. However, many of the BCP's can also be used in other areas that have similar combinations of habitats, species, postmining land uses, and objectives in the reclamation plan.

## 1.2 FACTORS AFFECTING PROTECTION AND ENHANCEMENT PRACTICES

In the past, numerous environmental problems were created by surface mining. The technique of contour mining with exposed highwalls and spoil materials left on the downhill slopes was commonplace. In these situations, highwalls created barriers to wildlife travel and became constant sources of acid drainage, while the spoil material caused severe erosion and land slides. The spoil often contained toxic material, which, when exposed to air and water, would produce severe acid mine drainage pollution. Current Federal and State surface mining laws have addressed these problems and have created regulations to help eliminate them.

Today, the single most important factor affecting fish and wildlife resources during surface mining operations is the failure to consider these resources during reclamation. They can be a valuable asset which the landowner and operator, with a little preplanning, can easily incorporate into any postmining land use objective. For example, a small investment in appropriate reclamation plantings and planting patterns can bring long-term benefits in terms of increased wildlife production. Money may actually be saved in some cases by designing sediment ponds so that they can be left on-site for waterfowl or fishery use. The landowner will benefit from the recreational aspects of wildlife on his land, while the operator will profit from the favorable public relations stemming from the maintenance of wildlife areas. Sport fishing and hunting is a big business, and development of areas conducive to this industry certainly provides a stimulus to the local economy.

Once initiated, some wildlife protection and enhancement practices require little maintenance, whereas others may require periodic upkeep. Ordinarily, an area which is reclaimed for a diversity of wildlife will require no maintenance. The area is fertilized and planted, and then allowed to regrow, providing benefits to many different wildlife species as regrowth continues. On the other hand, if a long-term management program for white-tailed deer is begun, certain practices will periodically have to be undertaken to ensure that the management goal is accomplished. These include such activities as periodic thinning of cover to create browse areas and replanting of grassy openings to provide high-quality food.

Ultimately, the question arises as to how much additional costs, if any, would be associated with providing protection and enhancement to fish and wildlife. An effort was made to answer this question to the extent that it could be done without knowing the site-specific characteristics of a particular mine. After reading the sections on Labor and Materials in Chapter 3, the operator should then seek the advice of local surface mining regulatory offices, fish and wildlife agencies and Soil Conservation Service officials, who can help "fine-tune" the cost information. In most cases, overall costs will be minimal and, as mentioned earlier, may actually save money. The final cost, however, will depend on the combination of techniques the operator and landowner wish to use to satisfy the land use objective at their particular mine site.

# 2. PLANNING

## 2.1 FISH AND WILDLIFE NEEDS

Fish and wildlife have certain basic habitat needs which must be met. These needs include the presence of food, cover, and water within the home range of the animal. These elements also have to be arranged in a particular pattern (interspersion) to ensure accessibility. A successful reclamation plan to enhance fish and wildlife resources must consider all these factors. If one or more of the elements is missing, no amount of effort can achieve the desired enhancement objective. For example, the properly-sized food plots, cover patches, and water resources for cottontail rabbit management might be incorporated into a reclamation plan, but if some of the escape cover is not located near enough to the food plots, predation and high mortality will more than likely cause the management effort to fail.

Not all animals have the same habitat requirements. In fact, even closely related species may have important differences in their habitat needs. It is these differences, when considered in a wildlife management plan, that will ultimately determine the success or failure of the plan. Following are general discussions on the habitat requirements of selected species in the central and southern Appalachian region.

### 2.1.1 Bobwhite Quail

Quail prefer areas with a good mix of brush, grass, and cultivated land. They feed primarily on seeds and scratch for food in semi-open areas. Lespedeza and ragweed are important quail foods, along with corn, smartweed, beggarweed, and partridge pea. In general, they require food sources within 75 to 100 feet of protective cover. Their nesting cover is usually located near openings in moderately dense tall grass and herbs, such as broomsedge and lespedeza. Escape cover is composed of brushy or thicket areas, often containing blackberries or sumac, which are not too dense to impede movement. In this region, bobwhite quail are not dependent on free water and can meet their water requirements through dew, rain, snow, succulent herbs, fleshy fruits, and insects. Seasonal movement rarely exceeds one mile, and the average home range of a covey is about 40 acres.

### 2.1.2 Cottontail Rabbit

Cottontail rabbits are found in areas where grassland, cropland, woodland, or mixtures of these habitat types are interspersed with brushy areas. Cottontails eat a variety of plants, both herbaceous and woody, depending on the season. Preferred foods are clovers, alfalfa, blackberries, dewberry, grain sorghum, and apples. Woody plants, such as sumac, willow, and orchard trees, are eaten more in the winter, when herbaceous plants are not available. These food sources are often adjacent to low, relatively dense ground cover, which provides escape cover. Nesting cover is usually in low vegetation, such as grasses, grass-forb mixtures, vines, or shrubs. Favorite sites are brier patches of low growing dewberry and blackberry. Most water requirements can be met by moisture from succulent plants and dew. Where all the above habitat requirements are met, the home range seldom exceeds 20 acres.

### 2.1.3 Ruffed Grouse

Ruffed grouse inhabit uneven-aged forests which are characterized by several size classes of trees. The birds consume mainly plants, browsing on woody buds and twigs, fleshy fruits, leaves, and seeds. Oak, grapes, and greenbrier are common food items. During the early juvenile period, insects make up a large part of their diet. Cover seems to be the most important habitat requirement. An area must have adequate escape, nesting, brooding, and winter cover to be suitable for grouse. Nesting cover is usually in second-growth hardwoods, such as sumac or pines, where undergrowth is sparse. The edge of cutover areas are favorite nesting sites. Escape cover is usually in thickets, vine tangles, and heavy shrub growth, while winter cover is in dense conifer stands for shelter and roosting. The home range of an adult bird is between 40 and 50 acres.

### 2.1.4 White-tailed Deer

White-tailed deer use a variety of forest, brushy edge, and field habitat types. Favored escape cover is composed of dense woodlands, wood thickets, conifers, or tall weeds. Japanese honeysuckle thickets and other shrubs are preferred concealment locations. During the winter, conifers provide cover, while tall grasses are used as resting areas. Occasionally, deer browse on the same plants that provide their cover. Preferred foods are woody shoots, grasses, forbs, and a variety of fruits and mast. Oaks are preferred foods, along with mountain laurel, maples, and greenbrier. Although deer require a source of open water daily, their water needs are met to some degree by succulent plants. These and other seasonal food and cover requirements usually cause the size of their home range to fluctuate between 300 and 640 acres.

### 2.1.5 Mourning Doves

These birds are usually found near open areas where grains are present. In the nesting season, however, mourning doves prefer trees and tall shrubs along the edges of fields and pastures. Conifers are favorite roosting spots. Because of their preference for grains, they are often found near agricultural areas, feeding on wheat, rye, or millet. However, natural foods, such as foxtail grasses, ragweed, and croton, are also important. Seeds from pines and other trees are taken only when the preferred cultivated grains are unavailable. Doves are highly mobile and will travel long distances for food, water, or gravel. In the southeastern U.S., water has not been shown to be a limiting factor for dove habitat.

### 2.1.6 Wild Turkey

The wild turkey's preferred habitat consists of a diversity of forest cover types and age classes, interspersed with small openings and cultivated land. Ideal range should also have a relatively open understory, consisting of shrubs, vines, saplings, and small trees. A high percentage of these trees and shrubs should be oaks and dogwood and other food-producing types, such as plums and grapes. Grassy openings of lespedeza and blackberry are important as breeding, nesting, and brooding cover, as well as food sources. Turkeys consume a wide variety of vegetable matter, mainly grasses, grains, and mast. In the summer, however, insects compose a large part of their diet. Turkeys are wide-ranging birds, sometimes covering 3.2 to 6.5 kilometers (2 to 4 miles) a day.

Relatively little acreage of ideal turkey range still exists anywhere in the Appalachians today. Modern forest management recommendations and practices are rarely geared to the multi-aged forest management concept, or the highly desirable multi-aged mixed forest type that provides desirable wild turkey habitat.

### 2.1.7 Small Furbearers

Red and gray fox, raccoon, opossum, and skunk are common small Appalachian furbearers. As a group, they eat both plant and animal foods, usually preferring animal foods when available. Important food items include mice, rabbits, frogs, and a variety of larval and adult insects. Fleshy fruits, such as persimmon and wild grapes, are also preferred over woody plant parts. Opossum are commonly found near wooded areas along streams and lakes, where skunks prefer weedy and brushy fields in semi-open country near water. Red and gray foxes use a variety of habitat types. Raccoons are commonly found in bottomland hardwood forests and marshes, but will use a variety of other habitats. Ground and tree dens are used for shelter, and tree dens are used for raising young. A source of open water is a daily requirement for these animals.

### 2.1.8 Nongame Birds

The Appalachians have a great variety of nongame birds (greater than 300 species), reflecting the large number of habitat types in the region. Songbirds, such as cardinals, mockingbirds, thrashers, towhees, and sparrows, are attracted to brushy areas and small clearings, whereas tanagers, warblers, vireos, and thrushes are common woodland species. Shorebirds, such as sandpipers, snipe, rails, and woodcock prefer marshy or swampy areas, while pastures and hayland attract killdeer, sparrows, blackbirds, meadowlarks, and bluebirds. Open areas around grasslands and scrub growth are ideal habitat for hawks and owls.

Nongame birds feed on a large number of both plant and animal foods. In general, insects are taken in the spring and summer when they are most available, while fleshy fruits and seeds are eaten in the fall and winter. Dogwood, wild cherry, pine, and oak are important woody plant species utilized for food, while panicgrass and ragweed are valuable non-woody food producers.

### 2.1.9 Threatened and Endangered Species

There are a few species of plants and animals which are presently in danger of becoming extinct or eliminated because of loss of suitable habitat. These species have very special needs which are met only under certain environmental conditions in relatively restricted geographic areas. For this reason, they are highly susceptible to changes in their habitat. In some instances, the Federal Endangered Species Act protects these species, while, in other cases, State regulations are in effect. It should be determined if one of such species occurs on a mine site, and, if so, the State regulatory authority should be informed of its presence. Proper authorities should evaluate the impact of mining on the species and determine the steps necessary to minimize the impact.

## 2.2 MANAGEMENT FOR FISH AND WILDLIFE

Active management for fish and wildlife is a viable part of the surface mining process which can provide long-term benefits to the landowner and society in general. This is an important part of the mining process and should be integrated into all phases of planning.

Long-range planning is necessary because the benefits from managing for fish and wildlife continue beyond the reclamation bonding period. For example, management for ruffed grouse, as mentioned above, would be a long-term goal over several years, realized only after second-growth hardwoods and other habitat needs were fully established on the site. In addition, some continued maintenance of the various vegetation phases may be necessary to keep the best habitat for the selected species. Thus, planning for wildlife should begin in the premining planning phase.

Certain considerations are necessary to accomplish effective long-range planning that allows for full development of fish and wildlife in the reclamation plan. These considerations include:

- literature review and synthesis
- baseline data gathering
- site potential evaluation
- goal-setting
- reclamation planning
- fish and wildlife planning

The baseline data provides the working foundation for effective management planning. Most of the information gathered in the permitting process can be used to help protect and enhance fish and wildlife resources. After the land use/cover types, wildlife habitat types, aquatic resources, types of fish and wildlife natural to the area, and unique habitat or biological features have been determined, all other planning can be more responsive to fish and wildlife needs.

Knowledge of the premine site characteristics will provide the basis for determining the site potential for fish and wildlife management. The success of species and their habitats naturally occurring in the area gives insight into potential success of managing selected species. The characteristics of the areas around the mine site will indicate the potential for selected species management on the site, particularly in cases where species' home ranges extend beyond the reclaimed site proper.

Building from the site characteristics and the site potential, realistic goals may be set for managing fish and wildlife. The landowner and/or operator may have preconceived ideas of the goals for postmining land use. Armed with the knowledge of baseline characteristics and site potential, a wildlife biologist can effectively incorporate fish and wildlife into the goals set for postmining land use. For example, green belts may be interspersed in residential/ commercial areas; buffer zones, wind breaks, hedgerows, food plots, and other vegetation patches, as well as impoundments, may be incorporated into grazing land, forest land, agricultural land, or other multiple land use alternatives. Fish and wildlife use is also a viable goal in itself.

Reclamation planning and fish and wildlife planning should be coordinated, whether the proposed postmining land use is solely for fish and wildlife or for some multiple use. After the goals are set, specific measures may be taken to apply the best current technology or practices to achieve fish and wildlife enhancement. Several Federal and State agencies can assist in planning and developing fish and wildlife habitat. Some State regulatory authorities and OSM offices have staff biologists who are experienced in mining technology, as well as wildlife and fisheries management. Other agencies, such as the Agricultural Stabilization and Conservation Service, Soil Conservation Service, State wildlife agency, State forestry service, and the U.S. Fish and Wildlife Service can provide additional guidance in special planning needs, where each agency has a particular expertise. Publications such as this one and others mentioned throughout this handbook can provide additional guidance.

# 3. BEST CURRENT FISH AND WILDLIFE ENHANCEMENT AND PROTECTION PRACTICES

## 3.1 PRELIMINARY PRACTICES USED TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

### 3.1.1 Roads

a. Purpose. Consideration of fish and wildlife in the design and construction of access and haul roads can greatly reduce impacts associated with these activities. A haul road with a 6-meter (20-foot) right-of-way covers 1 hectare (2.4 acres) every 1.6 kilometers (1 mile), thereby potentially affecting fish and wildlife resources over a large area. Negative roadway-related impacts, such as destruction of important habitat, wildlife disturbance from vehicles, and the creation of barriers to wildlife travel can all be reduced by proper road location, design, and construction. In most cases, there is minimal direct danger to wildlife from vehicle collisions. However, where this is a problem, the following techniques, coupled with a reduction of speed, will minimize the problem.

b. Development. Standards and specifications concerning the design and construction of roads are included in State and Federal surface mining regulations. These requirements, along with other engineering aspects dictated by site conditions, must be given first priority when designing and constructing roads. During the planning process, however, fish and wildlife protection and enhancement practices can easily be incorporated into most engineering plans. For example, management practices for sedimentation and siltation control are common elements of most road planning and are extremely important for protection of fish and water resources.

Destruction of wildlife habitat is often unavoidable when building roads, but careful siting can often reroute roads to avoid areas of significant value. This is especially important when critical habitat for an endangered or threatened species has been identified within an area. Adequate buffer zones should be provided for these sites (see Section 3.2.4 Buffer Zones). One way of preserving an area of high-value habitat, such as the edge between a woodland and an open field, would be to locate the road a hundred feet or so away from the edge, preferably in the field.

Roads can sometimes become barriers to normal wildlife movements by separating habitat types. While roads may not completely prevent movement of wildlife from one area to another, they create conditions that disrupt normal behavior. Roads can be located to avoid isolating habitat types and features, such as a watering area, from other wildlife-use areas.

When possible, locate roads below ridgelines (Thomas 1979). This tends to confine any wildlife disturbance created by traffic to one side of the ridge by using the ridgeline as a noise and visual screen. The benefits to be realized in the limiting of disturbance to wildlife must be carefully considered against the additional disturbance caused by having to cut roads into hillsides. Loose dirt cut from the roadway would be pushed downslope causing the loss of vegetation and siltation.

Direct mortality losses due to vehicle-wildlife collisions can be reduced by a number of measures. Animals can be discouraged from frequently using rights-of-way by management techniques that make the rights-of-way unattractive (see Section 3.2.6 Rights-of-Way Management). If necessary, fencing can be used to prevent wildlife from entering the roadway (Section 3.1.4 Fences). Fencing can also be used to guide animals to sections of roads where it is safer for them to cross. Sighting distances can be improved for vehicle operators and wildlife by using a larger radius for horizontal and vertical curves, and by increasing the right-of-way width on the inside of horizontal curves (Figures 3.1-1 and 3.1-2). This allows more avoidance time for drivers and more escape time for animals.

Roads which are to be removed and reclaimed after mining can be used to enhance wildlife habitat by innovative revegetation. Reclaimed roadbeds can be revegetated to increase habitat diversity by using plants suitable for wildlife and converting them to strip plantings (see Section 3.3.9 Planting Patterns). Roadbeds in forested areas can be reclaimed with grasses as open areas, while roads which pass through open fields can be planted with trees and shrubs to create cover and wildlife travel lanes.

c. Maintenance and management. Road design and construction techniques for fish and wildlife protection and enhancement generally do not require any management beyond normal road maintenance.

d. Labor/materials. Most of the effort for including fish and wildlife considerations in the design of roads is required during initial planning. Higher construction costs may be incurred in implementing some techniques, such as increasing a road's length when avoiding important habitat. In this and most other cases, the additional cost can be offset because no other mitigative measures are required.

e. Sources of information. Information concerning the location and significance of the fish and wildlife resources within the permit area can be obtained from the fish and wildlife inventory prepared for the permit application. Additional planning information and technical assistance can be requested from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- State Department of Highways/Transportation

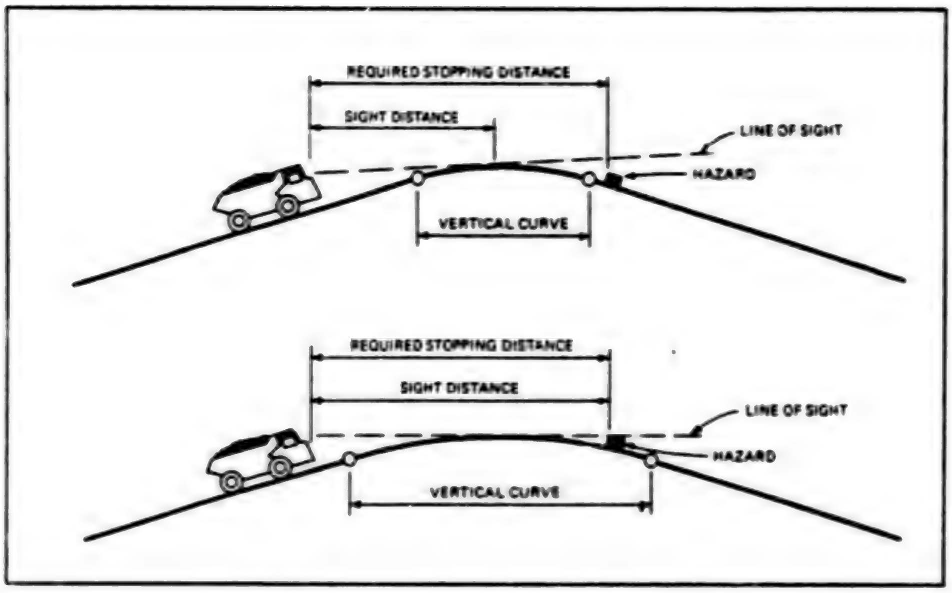


Figure 3.1-1. Sight distance on vertical curves (from Chironis 1978).

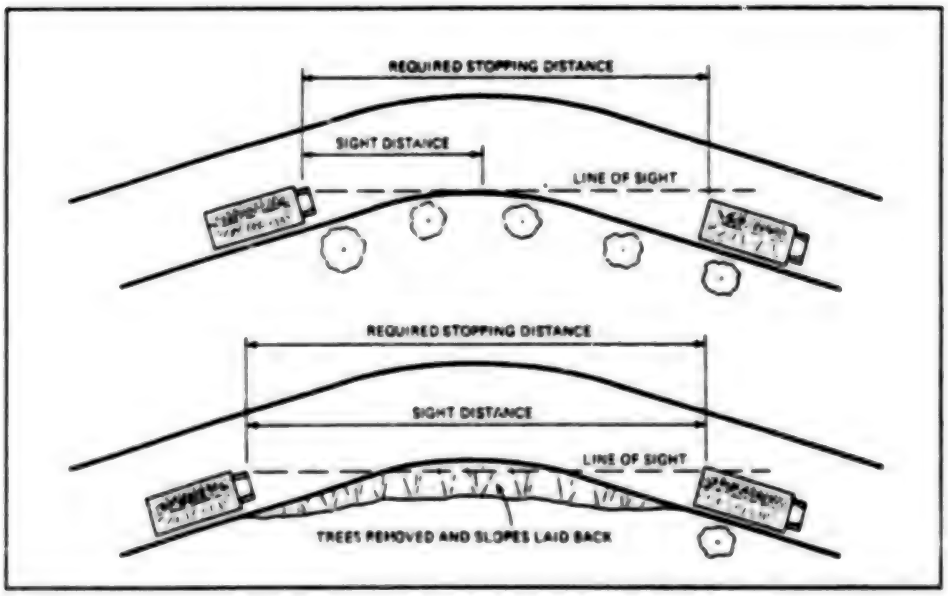

REQUIRED STOPPING DISTANCE
SIGHT DISTANCE
LINE OF SIGHT
REQUIRED STOPPING DISTANCE
SIGHT DISTANCE
LINE OF SIGHT
TREES REMOVED AND SLOPES LAID BACK

Figure 3.1-2. Sight distance on horizontal curves (from Chironis 1978).

References cited:

Chironis, N. P., ed. Designing safer and speedier haul roads. In: Coal age operating handbook of coal surface mining and reclamation, vol. 2: McGraw-Hill, New York; 1978.

Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. Agriculture Handbook No. 553: U.S. Department of Agriculture, Forest Service; published in cooperation with Wildlife Management Institute and U.S. Department of the Interior, Bureau of Land Management; 1979.

Additional references:

U.S. Forest Service. National forest landscape management. Volume 2, Chapter 4, Roads. Washington, DC; 1977.

Virginia State Water Control Board. Best management practices handbook: forestry. Planning Bulletin 317: Virginia State Water Control Board; 1979.

### 3.1.2 Powerlines

a. Purpose. The design and construction practices for powerlines can often significantly affect wildlife populations. Impacts to wildlife occur indirectly from design of the powerline and management of the right-of-way and directly from clearing, construction, and cleanup activities. In general, the larger the powerline system, the greater the degree of impact.

Because of the importance of powerline considerations in planning, several excellent publications have been made available to aid mine operators and other individuals responsible for installing lines. Most newly installed powerlines are built to prevent injury or death of birds coming in contact with the lines. The information presented in this section is therefore brief and not intended to take the place of other manuals. It is important, however, to highlight the design concerns and planning activities associated with powerlines to emphasize their overall significance in planning.

b. Design considerations.

- In areas frequented by large birds (e.g., eagles, hawks, and herons), power poles are favorite perches. Occasionally, the birds come in contact with wiring and fixtures on distribution line poles and are electrocuted. On any given system, relatively inexpensive modifications to frequently used power poles, over relatively short stretches of line, will greatly reduce mortality.

- Powerline routes should avoid open expanses of water and marshland which are used as flight lanes by migratory waterfowl and other birds. Areas heavily used as nesting and rearing sites by wildlife should be avoided. Construction of the line can cause short-term disturbances (i.e., traumatic dispersal and reduced numbers of offspring), while the location of the line may cause long-term impacts in the form of injury and mortality from collisions with electrical structures.

c. Construction considerations.

- Access and construction roads should be located in a manner that will minimize erosion. Road grades and alignments should follow the contour of the land with smooth, gradual curves when possible. The single greatest impact to most fish and wildlife during powerline construction results from stream degradation due to siltation from improperly sited roads.

- When clearing for the right-of-way, practices should be used which minimize the amount of cutting, reduce marring and scarring of the landscape, and reduce silting of streams. Appropriate cleaning techniques and machinery will greatly decrease the amount of time needed for regrowth of the wildlife habitat in the disturbed area.

- Where replanting of vegetation is required, native plants which have value as food and cover for wildlife should be given priority over introduced species of plants.
- Brush or small trees which are cut for clearing can be piled in such a way as to provide cover habitat for small game animals and birds.

d. Sources of information. Planning information and technical assistance can be requested from:

- State Regulatory Authority
- Office of Surface Mining
- U.S. Fish and Wildlife Service

Additional references:

Rural Electrification Administration. Powerline contacts by eagles and other large birds. REA Bull. No. 61-10; 1972.*

U.S. Department of Interior and U.S. Department of Agriculture. Environmental criteria for electric transmission systems; 1970.*

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 2. Eastern United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 3. Western United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

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*These guidance manuals are available at any Office of Surface Mining and at the central office of the State regulatory authority.

### 3.1.3 Stream Crossings

a. Purpose. Activities related to the installation and maintenance of stream crossings can have several adverse impacts on fish and wildlife. The shaping of the streambank and the removal of streambank vegetation not only destroys wildlife habitat cover, but also degrades aquatic habitat by subsequent silting over spawning and feeding areas. Improper maintenance of the crossing only aggravates the problem over time.

The crossing of streams by exploration, access, and haul roads should be kept to a minimum. Any stream crossing, whether temporary or permanent, must be approved by the regulatory authority. Where drainage structures are required for stream channel crossings, these structures must not affect the normal flow or gradient of the stream nor adversely affect fish movements, aquatic habitat, or related environmental values.

b. Illustration. During the exploration for coal and the construction of access roads, a temporary stream crossing is accomplished by simply fording the stream. Fording has a tremendous impact on the streambank and stream bottom and often can cause silting of downstream habitat. If vegetation is removed from the approaches to the stream, continuous erosion and subsequent siltation can become a major problem, requiring remedial action, such as discussed in Section 3.3.2.b on streambank protection. Temporary fords are an economical way to get over a stream, but if they are abused, remedial action can be costly, approaching the cost of installing temporary culverts or bridges.

If temporary fording is considered a viable option, careful planning can reduce the problems encountered. Several considerations are given below:

- Place rock or other stabilizing material on the approaches to reduce erosion and sedimentation of aquatic habitat.
- Align the crossing at right angles to the stream to minimize streambed disturbance.
- Choose a crossing point with stable bottom materials to prevent erosion.
- Revegetate the streambank after abandonment of the crossing to reestablish the riparian habitat and stabilize the bank to prevent continued erosion.

In the case of temporary or permanent culverts and/or bridges associated with access roads, the structure needed depends on the class of road and stream characteristics. The three classes of roads are defined as: (1) coal haul roads; (2) access roads, other than coal haul roads, that are to be used 6 months or longer; and (3) access roads, other than coal haul roads, to be used less than 6 months. It is advisable to use culverts and/or bridges with haul roads or access roads to be used longer than six months and, when a perennial stream is involved, these structures are appropriate for any class of road. Culverts and/or bridges must be designed to handle predicted site specific precipitation events. Specifications should be requested from the regulatory authority.

The size of the culvert, installation specifications, and type of culvert will depend on site-specific considerations. Engineering specifications should be obtained from publications that provide criteria for construction methods that are approved by the regulatory authority.

The type of culvert used will determine, to a large extent, how the natural stream conditions will be altered downstream and whether the culvert will act as a barrier to fish passage. Figure 3.1-3 illustrates three types of metal culverts which are commonly used. In addition to these, cylindrical concrete culverts are also used, but are discouraged because their smooth interior generates very high water velocities compared to corrugated metal culverts of the same diameter and gradient.

Several methods have been demonstrated to provide fish passage through culverts (Watts 1974; Evans and Johnston 1976). An arch culvert or bridge (Figure 3.1-4) has been shown to be effective since "natural" water flow may be maintained. This type of culvert disturbs the stream bed very little, and since the natural stream width is maintained, the water velocity does not significantly change. This culvert type comes in metal plates that are fabricated on site.

Another culvert which allows fish to pass with a minimum of disturbance is the pipe arch culvert. It can be used in smaller streams where the steel arch culvert cannot be used. Water velocities are a real problem with this type, but near-normal flow conditions can be maintained if the gradient is kept below 1 percent. A major problem with these culverts is that, during periods of low flow, the water level in the culvert bottom is so shallow that fish cannot pass through. This flow problem may be reduced through the use of baffles (Figure 3.1-5). Baffles are also used to reduce water velocity where culvert design and installation features cannot effectively be used for flow reduction. Information on the overall effectiveness of baffle designs is lacking, but is discussed to some extent in McKinley and Webb (1956) and Yee and Roelofs (1980). Normally, baffles are not recommended due to the additional required maintenance and the need to constantly remove debris (Yee and Roelofs 1980).

The least desirable culvert type with respect to fish passage is the standard, round, corrugated culvert (Figure 3.1-3). Installation of this type of culvert requires narrowing the stream width, which means that, to keep water velocity low, the gradient must be near zero. Normal installation of this type of culvert usually leaves an elevated outfall, which creates a barrier to fish passage. However, there are several ways that an outfall barrier associated with a round culvert can be eliminated. One solution is to construct small or low-head dams (Figure 3.1-6) in the tailwater, which will raise the water level to the culvert outfall. Dams create barriers if they are too high (> 0.3 meters [> 1 foot]), and, if dam height becomes a problem,

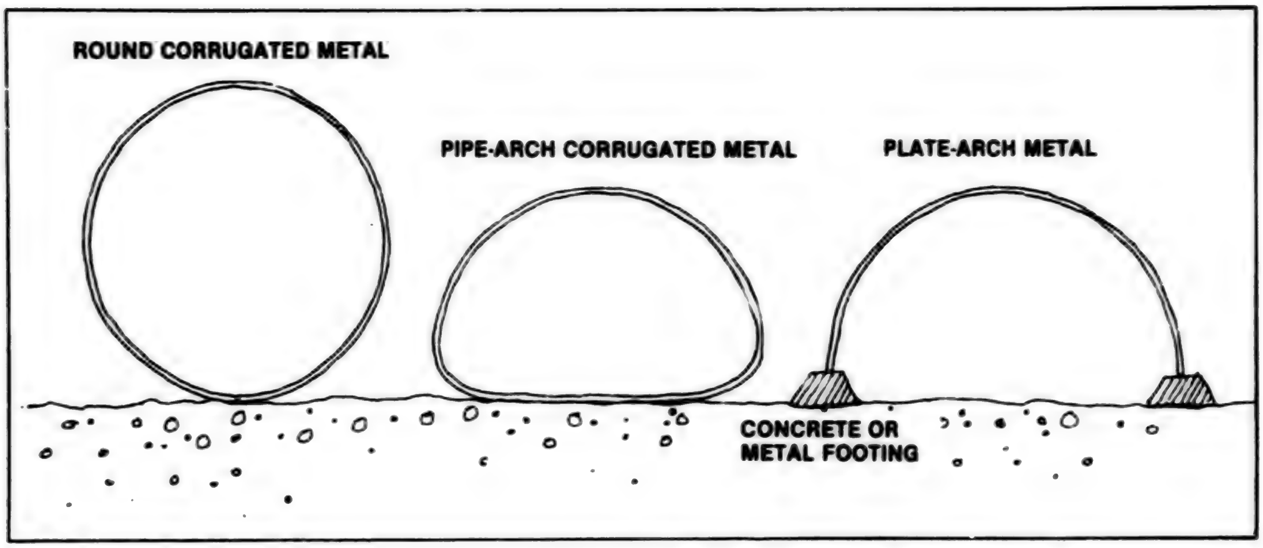

Figure 3.1-3. Cross sections of metal culverts (from Yee and Roelofs 1980).

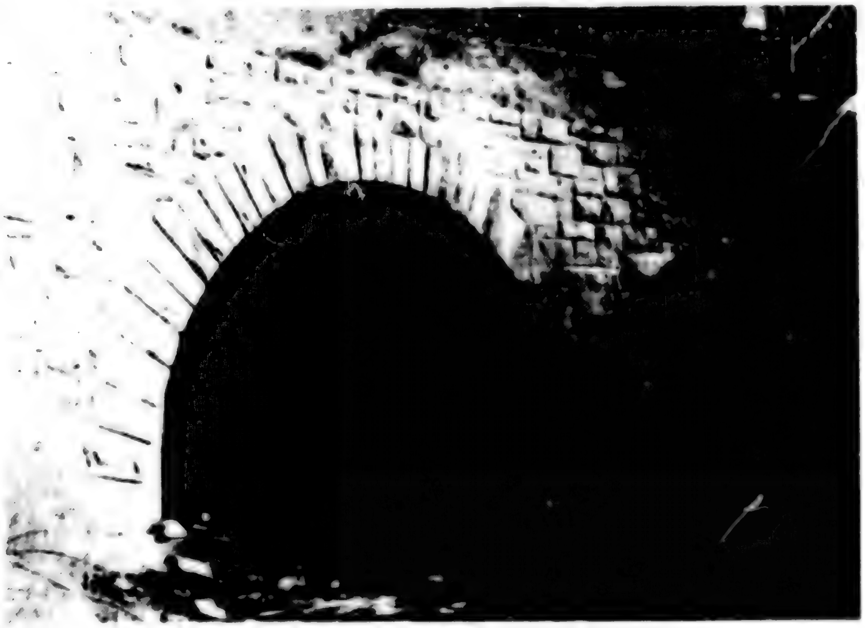

Figure 3.1-4. The arch bridge, like an arch culvert, provides for fish passage (from Nelson et al. 1978).

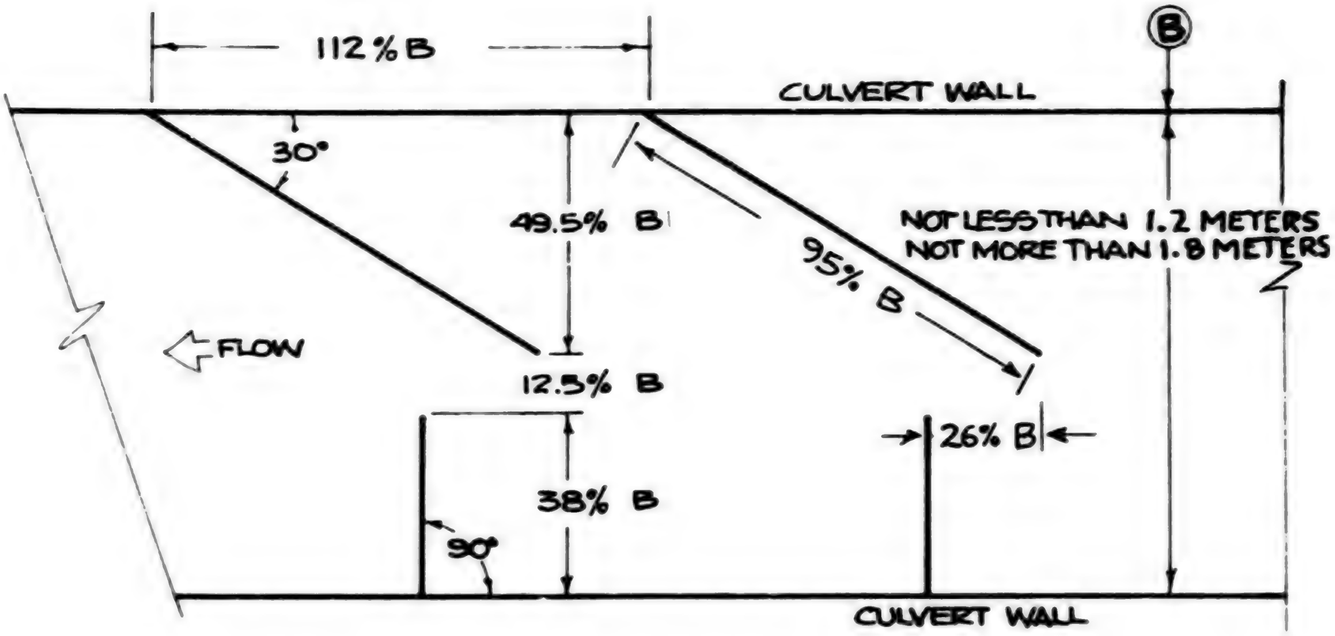

Figure 3.1-5. Baffle placement in a metal culvert (from Yee and Roelofs 1980). Measurements are expressed as percentages of the clear width of the baffled section of culvert (B). Baffles are 0.3 meter (1 foot) high and 13-15 cm (5-6 inches) wide.

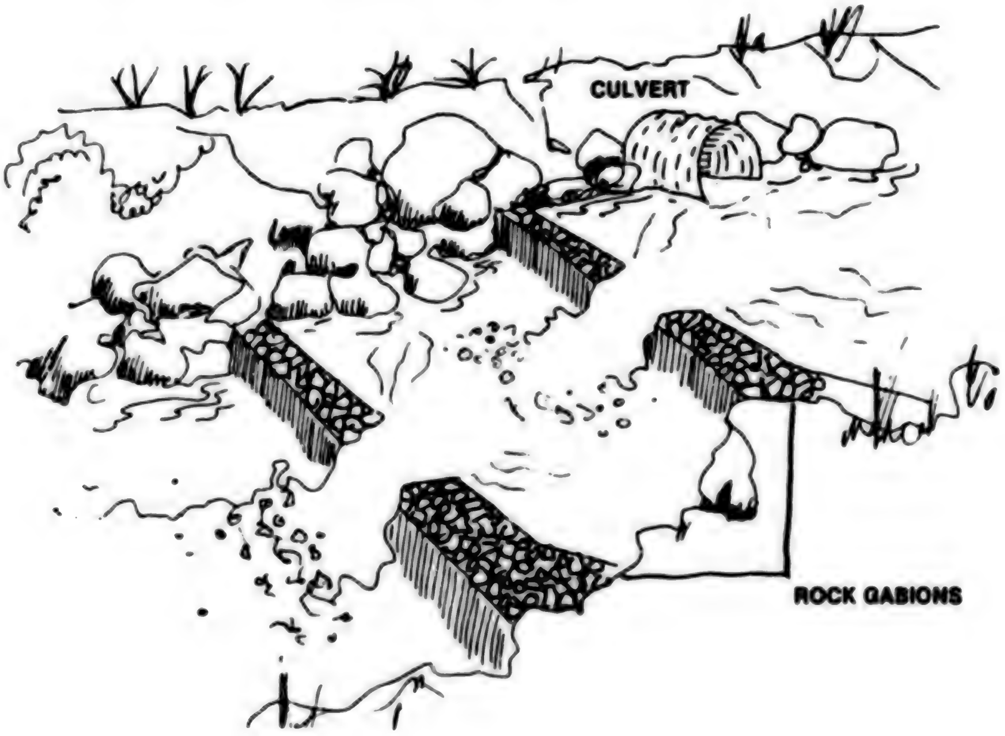

Figure 3.1-6. The use of low-head dams to raise the water level to culvert level.

the dam should be notched to prevent it from becoming a barrier. Dams may be constructed from rocks simply laid in the stream, gabions, or other suitable material.

In streams that have a very large fluctuation in water flow, outfall barriers can occur, which can prevent fish passage during low flow periods. This problem is counteracted with stacked culverts (Figure 3.1-7), which are simply multi-culvert installations in which small-sized culverts are placed low to concentrate water at low flow and larger culverts are placed higher to handle high flow (Yee and Roelofs 1980).

To summarize, several factors must be considered to minimize the impact of stream crossings on fish movement (Yee and Roelofs 1980):

- Where possible, avoid the use of round culverts if fish passage is a problem. Arch culverts or bridges should be used, especially where culverts would be > 30.5 meters (> 100 feet) in length or the gradient > 2 percent.
- Design the culverts to handle maximum flow (see above).
- Single culverts are better than stacked culverts, because debris collection is less likely. Use only multi-culverts in situations of large flow fluctuation.
- Install culverts with the smallest gradient possible (zero preferable). Reduce fish passage restriction and streambed lowering by placing the culvert just under the normal stream grade.
- Use larger culverts or reduced gradients to avoid baffling if at all possible.
- Do not place riprap or materials used to stabilize culverts and bridges where they will impede channel flow.

c. Maintenance and management. In the case of fords, stable stream approaches must be maintained. Periodic checks of riprap or other stabilizing material may be necessary. Revegetation of the streambank is appropriate to maintain the riparian habitat.

Debris that collects in the culvert or against bridge structures can prove to be a barrier to fish movement. Periodic checks should be made to remove such materials. Culverts and bridges would have to be maintained within appropriate standards as specified by the regulatory authority.

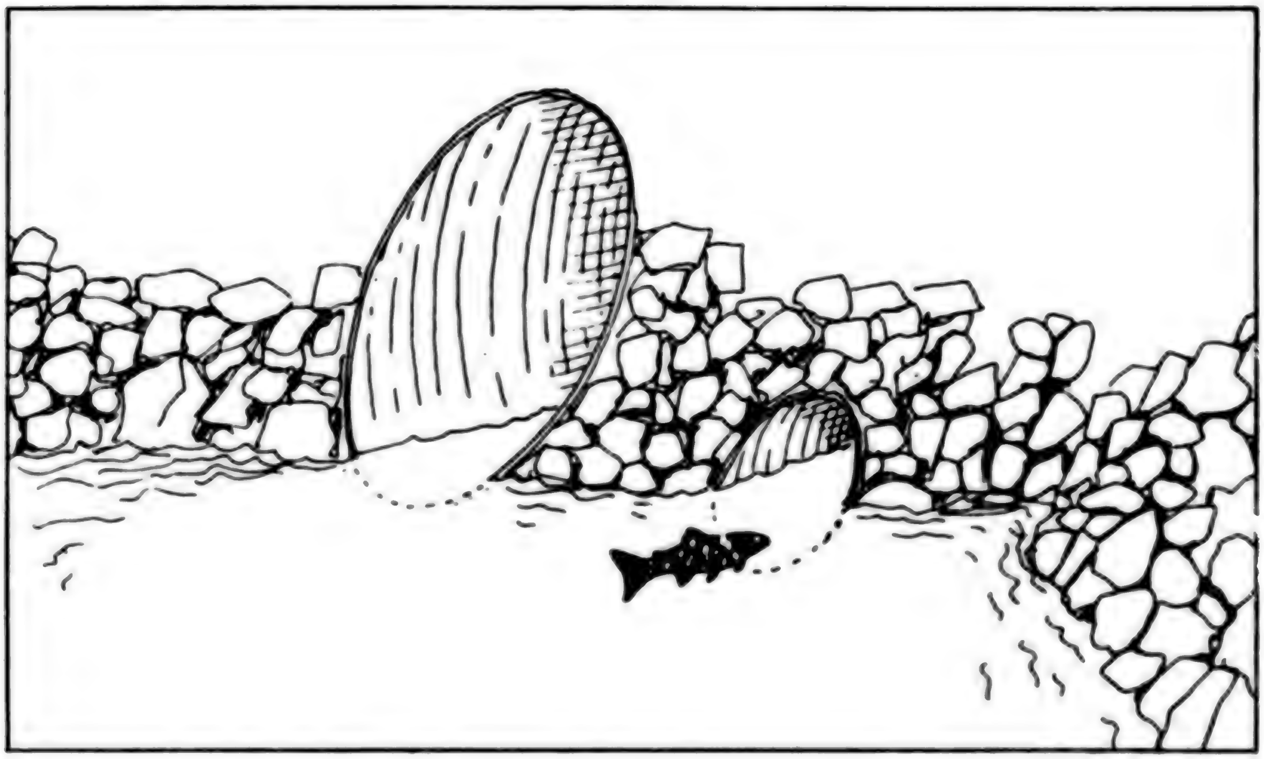

Figure 3.1-7. Multiple or stacked culverts used to compensate for water flow fluctuations. Small culverts concentrate low flow and large culverts handle high flow (after Yee and Roelofs 1980).

d. Labor/materials. Culvert or bridge materials, equipment operation, fill haulage, fill placement, and labor would vary in cost according to site-specific considerations. Most road building contractors and State highway department personnel have ready access to the cost of such materials. Some States maintain a Unit Bid Price List that contains costs of these and related activities. Some sample costs of culverts are given below:

| Corrugated Metal Pipe Culvert | Average Price |
|---|---|
| 91 cm (36 inch)-14 gauge | $ 27.23 per 0.3 m (lin ft) |
| 122 cm (48 inch)-14 gauge | $ 34.82 per 0.3 m (lin ft) |
| 183 cm (72 inch)-16 gauge | $ 66.43 per 0.3 m (lin ft) |
| Corrugated Metal Area Culvert | |
| 89 x 61 cm (35 x 24 inch)-14 gauge | $ 24.06 per 0.3 m (lin ft) |
| 125 x 84 cm (49 x 33 inch)-14 gauge | $ 30.78 per 0.3 m (lin ft) |
| 285 x 191 cm (112 x 75 inch)-12 gauge | $110.00 per 0.3 m (lin ft) |

e. Sources of information. Additional guidance and information on stream crossings can be obtained from:

- State Regulatory Agency
- Office of Surface Mining
- U.S. Forest Service
- State Highway Department
- U.S. Army Corps of Engineers
- Soil Conservation Service

References cited:

Evans, W. A.; Johnston, F. B. Fish migration and fish passage - A practical guide to solving fish passage problems. U.S. Forest Service; June 1976.

McKinley, W. R.; Webb, R. D. A proposed correction of migratory fish problems at box culverts. Washington Department of Fisheries, Fish. Res. Paper 1(4):33-45; 1956.

Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. U.S. Fish and Wildlife Service, Western Energy and Land Use Team, FWS/OBS-78/56; October 1978.

Watts, F. J. Design of culvert fishways. Moscow, Idaho: Water Resources Research Institute, University of Idaho; May 1974.

Yee, C. S.; Roelofs, T. D. Planning forest roads to protect salmonid habitat. USDA, Forest Service, Pacific Northwest Forest and Range Expt. Sta., Gen. Tech. Rept. PNW-109; July, 1980.

Additional references:

Grim, E. C.; Hill, R. D. Environmental protection in surface mining of Coal. U.S. Environmental Protection Agency, Cincinnati, OH, EPA-670/2-74-093; October 1974.

### 3.1.4 Fences

a. Purpose. In the central and southern Appalachians, sediment ponds sometime contain highly acidic water or hazardous concentrations of toxic materials (i.e., pesticides, herbicides). Where this is the case, wildlife should be prevented from using the pond by enclosing it with woven or mesh wire fencing. Of particular importance is the need to exclude white-tailed deer, which commonly use sediment ponds as a source of water. Other smaller mammals, such as raccoon and foxes, can also be prevented from using the pond through modifications of fencing design.

It is important to point out that the majority of sediment ponds which are constructed in the Appalachians do not need exclosure fencing. However, the regulatory authority must make the determination of whether or not a fence should be required, based on the information submitted in the mine plan (i.e., the extent of acid-bearing strata, the use of potentially toxic substances on site, and the potential danger and problems if wildlife do come in contact with the sediment pond).

b. Development. Currently, the most effective fence in terms of performance and cost for excluding deer is the 'slanting' deer fence. Instead of being upright, as most fences are, the slanting fence is inclined at an angle with the high edge pointing in the direction of approach. The angle of slant is approximately 45° and is effective primarily because it acts as a behavioral barrier to deer movement. Deer often attempt to go under a fence and are discouraged by the fence slanting over their backs. They will not attempt to jump such a fence.

The slanting fence can be constructed in two different ways. Longhurst et al. (1962) designed a fence which consisted of mesh wire supported between two guy wires (Figure 3.1-8). The main disadvantage to this type of fence is that, in areas of heavy snowfall, a fence of this design may be crushed by the weight of snow. A sturdier slanting fence was proposed by Messner et al. (1973), and consists of a 2.1-meter (7-foot) inclined sloping post fastened to each vertical line post for additional support against heavy snowfall (Figure 3.1-9).

Generally speaking, in the mountains from upper Tennessee northward into Kentucky, West Virginia, and Virginia, the fence with wooden diagonal supports would be the most appropriate design to use. Mountain snowfalls in these areas often are in excess of one foot for two months of the winter, and drifts will often times reach three feet or more. These effects, combined with ice storms, would crush or make ineffective a less-sturdy fence. However, from mid-Tennessee southward, the wire mesh and guy wire slanting fence should be durable enough to withstand the environmental conditions of this region.

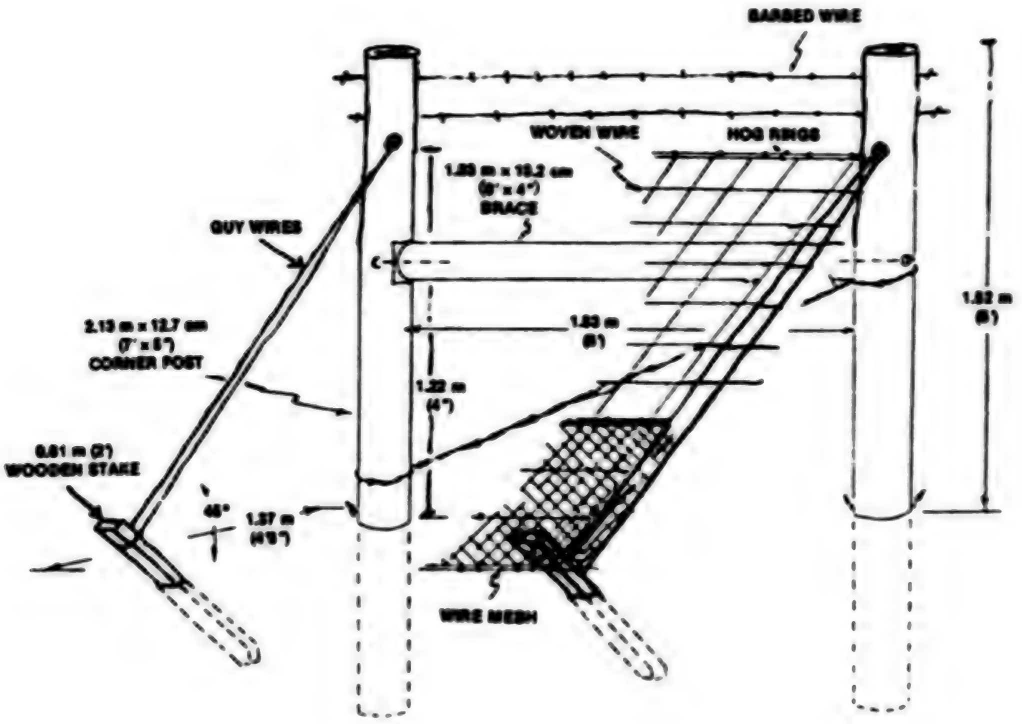

Figure 3.1-8. Diagonal view of slanting deer fence showing guy wire support construction (after Messner et al. 1973).

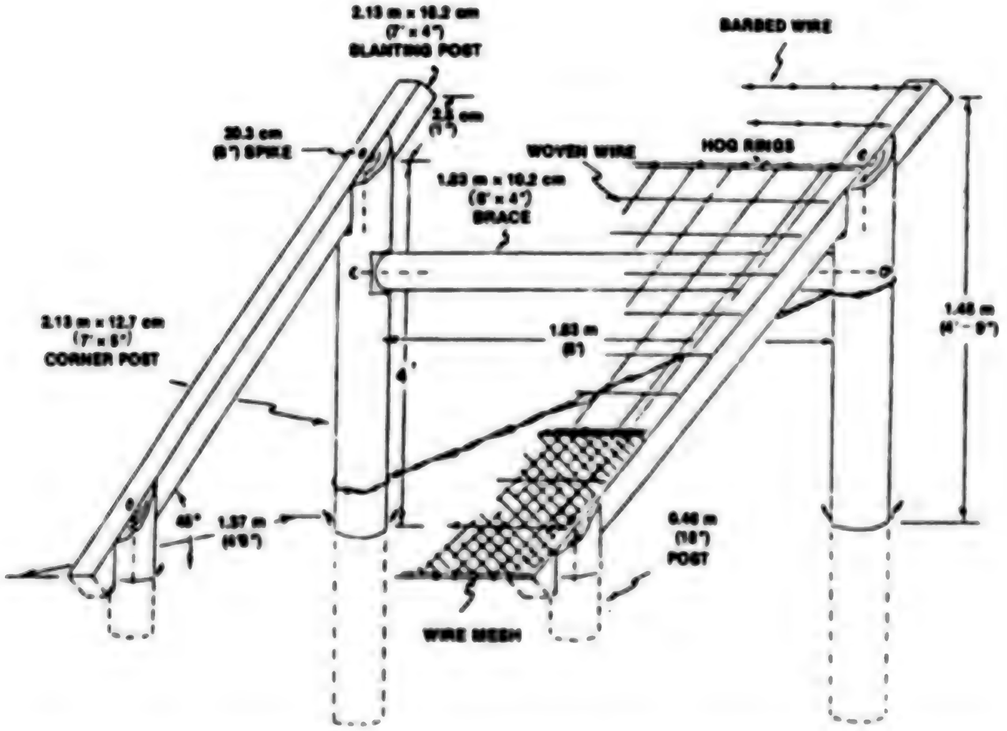

Figure 3.1-9. Diagonal view of slanting deer fence showing wooden diagonal post construction (from Messner et al. 1973).

The slanting fence of Messner et al. (1973) is constructed in the following manner:

> A 2.1-meter (10-cm square) [7-foot (4-inch square)] sloping post is fastened to a vertical post 1.2 meters (4 feet) above ground level with an 20-cm (8-inch) spike. A 0.3-meter (1-foot) overhang is provided by the extension of the top of the slanting post past the vertical post. The bottom of the sloping post nests on the ground 1.4 meters (4.5 feet) from the vertical line post, forming an angle of approximatley 45°. The 1.8-meter (6-foot) line posts are recommended to be set in 0.6-meter (2-foot) deep holes spaced 3.7 meters (12 feet) apart.
>
> Starting at ground level and working up, the following fencing materials (as indicated in Figure 3.1-9) are fastened to the upper side of the sloping posts: (1) four strands of barbed wire; (2) one 122-cm-wide (48-inch-wide) woven wire; and (3) two more strands of barbed wired. An additional 61-cm (24-inch) wire mesh laid across the barbed wire between the ground level and the woven wire would discourage small mammals from entering between the lower barbed wire strands.
>
> At the corners, two 2.1-meter (7-foot) vertical posts are set 76 cm (30 inches) deep and 1.8 meters (6 feet) apart on each side of the corner. These are braced with a 1.8-meter (6-foot) line post placed horizontally about 0.9 meter (3 feet) above ground level. The sloping posts at the corners are secured at ground level with an 20 cm (8-inch) spike to an 46-cm (18-inch) section of a 10-cm-diameter (4-inch-diameter) post set approximately 30 cm (12 inches) deep. Both 2.1-meter (7-foot) and 46-cm (18-inch) vertical corner posts are notched at the top with a 45° cut to receive the sloping posts and hold them against horizontal stress. A pie-shaped wedge of woven wire and several strands of barbed wire are then used to close the opening at the corner.

A modification of the slanting deer fence, as originally proposed by Longhurst et al. (1962), can be constructed as follows:

> Basically, the same design principles and materials as discussed above (Messner et al. 1973) can be utilized with following changes:
>
> (1) Two guy wires (No. 9 galvanized wire), 1.9 meters (6 feet) long, will replace each 2.1-meter (7-foot) x 10-cm (4-inch) slanting post. the woven wire will then be 'sandwiched' between the guy wires.
>
> (2) The guy wires will be anchored to the ground by 0.6-meter-long (2-foot-long) wooden support stakes driven into the ground at an angle away from the fence.

(3) The two upper strands of barbed wire will be placed at the top of a new 2.1-meter (7-foot) high vertical post (previously 1.8 meters [6 feet] high).

c. Maintenance and management. Essentially no maintenance would be required of the fencing during the time when toxic materials would pose a danger to wildlife. After the pond and/or toxic materials were removed, the fencing could easily be dismantled for use elsewhere.

d. Labor and materials. Table 3.1-1 gives the specifications and costs of materials necessary to enclose a square approximately 0.13 hectare (0.33 acre) plot (36 x 36 meters [120 X 120 ft]) with the slanting deer fence proposed by Messner et al. (1973). Approximately two man-weeks would be required to install this fence. Comparative costs of materials for the fence proposed by Longhurst et al. (1962) are given in Table 3.1-2. Installation costs in terms of man-hours of effort for the Longhurst fence would be similar to the hours required for the Messner fence.

Upright fences are still being used in some areas of the country to exclude deer, but, to be effective these fences need to be approximately 2.4 meters (8 feet) high. Cost considerations to make when comparing slanted vs. upright fences include the following:

- The shorter posts of the slanted fence are cheaper than the longer posts of the upright fence, but more posts are needed in the slanted fence.
- The amount of mesh wire required for the slanting fence is approximately half that required for the upright fence.
- More barbed wire is needed in a slanting fence. Six strands (two above and four below) are used on the slanting fence, while only two are used (top and bottom) on an 2.4-meter (eight-foot) high upright fence.
- Based on material costs, a slanting fence with wooden supports costs $21.40 per 5 meters (rod) compared to $31.80 per 5 meters (rod) for an upright fence.

e. Sources of information. Additional information can be requested from:

- State Regulatory Authority
- State Fish and Game Agency
- Office of Surface Mining
- U.S. Forest Service
- U.S. Fish and Wildlife Service

Table 3.1-1. Specifications and costs for a slanting deer fence (36 x 36 meters [120 x 120 ft]) with wooden supports[a]

| Description | Specification | No. | Unit | Unit cost | Total |
|---|---|---|---|---|---|
| Posts | | | | | |
| Corner | 2.1 m x 12.7 cm (7' x 5") | 16 | ea. | $ 5.00 | $ 80.00 |
| Line and Brace | 1.8 m x 10.2 cm (6' x 4") | 40 | ea. | 3.90 | 156.00 |
| Ground Support Post | 1.8 m x 10.2 cm (6' x 4") | 4 | ea. | 3.90 | 15.60 |
| Slanting | 2.1 m x 10.2 cm (7' x 4") | 48 | ea. | 4.10 | 196.80 |
| Wire (galvanized) | | | | | |
| Woven for main course | 12½ gauge mesh, horizontal strands, 10 gauge, 122 cm (48") wide, 101 m long | 1.5 | rolls | 37.80 | 56.70 |
| Barbed, for fence top, bottom and bracing | 12½ gauge, 2 pt., 402 m long (79.9 rods) | 1<br>402<br>(80 | roll<br>m<br>rod) | 35.45 | 35.45 |
| Wire mesh at fence bottom to exclude small animals | 45.7 m x 7.3 m with 0.3 cm (150' x 24' with 1") hexagon openings | 3.2 | rolls | 13.23 | 42.32 |
| Staples | 4.4 cm (1 3/4") | 4.5<br>(10 | kg<br>lbs.) | 0.70 | 7.00 |
| Hog Rings | | | | | |
| Join mesh with woven and barbed wires | No. 1 | 1000 | ea. | 0.015 | 15.00 |
| Nails | 20 cm (8") spike | 80 | ea. | 0.15 | 12.00 |
| Total cost | | | | | $616.87 |
| Cost per meter | | | | | $ 4.28 |
| Alternate Plan with Change in Slanting Post Specifications | | | | | |
| Posts | | | | | |
| Slanting | 2.1 m x 7 cm (7' x 3") | 48 | ea. | 2.40 | 115.20 |
| Other Materials with No Change | | | | | 420.07 |
| Total cost | | | | | $535.27 |
| Cost per meter | | | | | 3.72 |

[a] Costs are base dollars (1981)

Table 3.1-2. Specifications and costs for a slanting deer fence (36 x 36 meters [120 x 120 ft]) with wire supports[a]

| Description | Specification | No. | Unit | Unit cost | Total |
|---|---|---|---|---|---|
| Posts | | | | | |
| Corner | 2.1 m x 12.7 cm (7' x 5") | 16 | ea. | $ 5.00 | $ 80.00 |
| Line | 2.1 m x 10.2 cm (7' x 4") | 48 | ea. | 4.10 | 185.00 |
| Ground Support Post | 1.8 m x 10.2 cm (6' x 4") | 4 | ea. | 3.90 | 15.60 |
| Slanting | 2.1 m x 10.2 cm (7' x 4") | 48 | ea. | 4.10 | 196.80 |
| Wire (galvanized) | | | | | |
| Smooth | 9 gauge<br>213.4 m (700 ft) | 14 | rolls | 4.20 | 58.80 |
| Woven for main course | 12½ gauge mesh, horizontal strands, 10 gauge, 122 cm (48") wide, 101 m long | 1.5 | rolls | 37.80 | 56.70 |
| Barbed, for fence top, bottom and bracing | 12½ gauge, 2 pt., 402 m long | 1<br>402<br>(80 | rolls<br>m<br>rod) | 35.45 | 35.45 |
| Wire mesh at fence bottom to exclude small animals | 45.7 m x 7.3 m with 0.3 cm (150' x 24' with 1") hexagon openings | 3.2 | rolls | 13.23 | 42.32 |
| Staples | 4.4 cm (1 3/4") | 4.5<br>(10 | kg<br>lbs.) | 0.70 | 7.00 |
| Hog Rings | | | | | |
| Join mesh with woven and barbed wires | No. 1 | 1000 | ea. | 0.015 | 15.00 |
| Wooden Support Stakes | 0.6 m (2') long | 48 | ea. | 1.10 | 52.80 |
| Nails | 20 cm (8") spike | 32 | ea. | 0.15 | 4.80 |
| Total cost | | | | | $750.27 |
| Cost per meter | | | | | 5.21 |

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[a] Costs are base dollars (1981)

References cited:

Longhurst, G. A.; Jones, M. B; Parks, R. R.; Neubauer, L. W. Fences for controlling deer damage. California Agricultural Experiment Station Service. Circular 514; 1962.

Messner, H. E.; Dietz, D. R.; Garrett, E. C. A modification of the slanting deer fence. J. Range Manage. 26(30):233-235; 1973.

Additional references:

Halls, L. K.; Boyd, C. E.; Lay, D. W.; Goodrum, P. D. Deer fence construction and costs. J. Wildl. Manage. 29(4):885-888; 1965.

## 3.2 PRACTICES USED DURING MINING TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

### 3.2.1 Overburden and Soil Handling

a. General procedures. Incorporating the proper procedures for handling overburden and soil materials into the mine plan is necessary to insure successful reclamation. The decisions on how these materials will be handled will depend in large part on their physical and chemical characteristics, which are determined during the premining analysis of the overburden. The amount of sampling required for the analysis depends on applicable State and Federal regulations, the amount of on-site disturbance, and problems foreseen on the site based on other activities in the area.

The object of the sampling and analysis is to obtain a general knowledge of the soils and overburden and to detect inhibitory zones in the overburden. Site-specific procedures can then be instituted to provide the best solution to problems in toxicity, salinity-sodicity or acidity, infertility, weatherability, and erodibility. Successful reclamation is dependent on the ability to stabilize a site and to reestablish a good vegetative cover.

Depending on the site-specific situation, mining procedures almost always include:

- segregation and treatment of toxic materials.
- segregation and amendment of topsoil, subsoil, and/or soil substitute to be used as a medium for revegetation.

For specific requirements within any one State, the State regulatory authority must be contacted and its regulations followed.

Each mine site will require different procedures, depending on the physical and chemical characteristics of the overburden. It is highly advisable to solicit the help of experts to identify potential problem areas so that mitigative actions can be incorporated into the overall mine plan. The regulatory authority can advise on problems that have occurred in the area, and local soil conservationists can advise on problems related to soil and overburden handling to achieve the best reclamation. General publications, such as the following, provide overviews that can aid in planning:

- U.S. Department of Interior. Small Surface Coal Mine Operators Handbook - Water Resources Protection Techniques. Washington, DC: Office of Surface Mining; 1980.
- U.S. Forest Service. User Guide to Soils - Mining and Reclamation in the West. Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, UT. Gen. Tech. Rpt. INT-68, SEAM; 1979.

- U.S. Forest Service. Procedures Recommended for Overburden and Hydrologic Studies on Surface Mines - Thunder Basin Project. Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, UT. Gen. Tech. Rpt. INT-71, SEAM; 1980.

Information provided in the following sections is designed to provide further guidance in handling overburden and soil materials.

b. Selective placement and stabilization of spoils and topsoil.

PURPOSE

In the mining process, it is important to identify problem-producing strata in the overburden so that they can be handled in such a manner that they will not create spoils that are toxic to plants or contribute acid pollution to streams. Basically, this means separating acid-forming and toxic-forming strata from the neutral or non-acid-forming and non-toxic-forming strata and burying the acid- and toxic-forming strata at the proper depth within the neutral material to prevent leaching, contact with ground water, and contamination of topsoil or soil substitute.

Placement planning and procedures should consider the following:

- Whether storage needs will be permanent or temporary.
- Quantity and characteristics of the material to be stored.
- Potential toxicity and stability problems during storage.
- Slope and aspect of the storage pile.
- Access of the mine operator to the storage site.
- Effect of wind and water on the storage site and the need for erosion control practices.
- Effects of material storage on adjacent land uses.
- Treatment, if necessary, to neutralize the material before placement.
- Location of the stored acid-forming or toxic-forming material within the fill to segregate material from aquifers.
- Location of fill to segregate it, or runoff from it, from water courses.

DEVELOPMENT

In most cases, because of the mining methods used in the Appalachians, the overburden will be placed directly back into the mining pit as backfill.

However, when storage of the material is required, it may be necessary to treat the spoil so that leaching of toxic substances and/or valuable nutrients can be prevented. If the spoil will support plant growth, seeding of the storage pile may suffice. If not, other materials which will encourage plant growth (e.g., topsoils, fertilizers, etc.) may have to be mixed with the spoil so that germination of seeds will occur (Section 3.3.1, Seedbed Preparation).

A measurement of the pH of spoil is the most commonly used method to identify the spoil's ability to support vegetation. In States, such as Kentucky and West Virginia, which require mine spoils to be limed to a specific pH range before planting grasses and legumes, compliance with regulations will alleviate most pH problems in planting. However, it is a wise practice, before seeding herbaceous plants on mine spoil, to test the pH of the spoil for compatibility with plantings. Table 3.2-1 lists some quick-cover plant species suitable for temporary spoil cover in central Appalachia, along with planting dates and seeding rates. The lower pH range for all the plants in Table 3.2-1 is between 4.0 and 5.0.

Mine spoils in the Appalachians are commonly deficient in some of the nutrients necessary for plant growth. Nitrogen and phosphorus are most often the ones needed. Nitrogen is almost exclusively a topsoil component, while phosphorus usually exists either as an insoluble component or in very small amounts. Some spoils in the region have also been found to have reduced amounts of calcium and magnesium. These nutrient deficiencies can usually be overcome with the addition of fertilizer.

Protection of topsoils and topsoil substitutes that will later be used to support plant growth are very important. Initial placement must be selective so as to protect the material from wind and water erosion and to protect the physical and chemical qualities while those materials are in storage. Topsoils which have had nutrients leached from them will often require substantial amounts of fertilizer to amend them to a productive level.

A preliminary analysis of the overburden may indicate that a shallow topsoil (less than 15 cm [6 inches]) is present. Where this is the case, it is often difficult to remove only the topsoil for storage. However, most States will accept the upper 15 cm (6 inches) of soil (in the case of a shallow topsoil) as the strata to be stockpiled and later distributed as the surface soil layer. The premining analysis may also indicate that some other strata can be used as a plant growth medium. Additional stockpiling of these strata at little expense may pay off later by enhanced regrowth during reclamation.

Replacement of the spoil and topsoil on the mined area during reclamation will require that the more toxic spoils be placed in the mine cavity with other spoil material placed around it. The spoil material should be placed and compacted in such a way as to prevent leaching or contamination of ground water. Spoil and other plant growth medium should be placed on top of the toxic material to prevent leaching of toxic substances. In determining how much "safe" overburden is needed to adequately cover toxic spoil, the following factors should be considered: the texture or particle size composition of both materials; the total amount of acidity in the toxic spoil; the degree of

Table 3.2-1. Suggested quick-cover species for spoil pile stabilization in the Central and Southern Appalachian Region (after U.S. Forest Service 1975)[a]

| Planting Period | Species | Seeding Rate per 0.4 hectare [kg (lbs)] |
|---|---|---|
| Feb. 1 - Apr. 1 | Perennial ryegrass | 6.8 (15) |
| | Annual ryegrass | 4.5 (10) |
| | Balbo rye | 25.4 (56) |
| | Redtop | 1.4 (3) |
| | Weeping lovegrass | 1.1 (2.5) |
| | Browntop millet | 4.5 (10) |
| Apr. 1 - May 15 | Weeping lovegrass | 1.1 (2.5) |
| | Perennial ryegrass | 4.5 (10) |
| | Browntop millet | 4.5 (10) |
| May 15 - Aug. 1 | Pearl millet | 4.5 (10) |
| | Foxtail (German) millet | 4.5 (10) |
| | Weeping lovegrass | 1.1 (2.5) |
| Aug. 1 - Oct. 1 | Perennial ryegrass | 6.8 (15) |
| | Balbo rye or winter rye | 25.4 (56) |
| | Abruzzi rye | 4.5 (10) |
| | Winter wheat | 27.2 (60) |
| | Annual ryegrass | 4.5 (10) |
| Oct. 1 - Nov. 15 | Balbo rye or winter rye | 31.8 (70) |
| | Abruzzi rye | 4.5 (10) |
| | Winter wheat | 34.1 (75) |
| | Annual ryegrass | 5.5 (12) |
| | Field bromegrass | 4.5 (10) |

[a] Within a planting period, use only one of the listed plant species at the recommended seeding rate.

internal drainage in both materials; and the amount of lime used on the toxic spoil before covering. In general, a minimum thickness of 1.2 to 1.5 meters (4 to 5 feet) of "safe" covering material is suggested (U.S. Forest Service 1975). Precautions should also be taken to isolate toxic-forming materials from any ground water flow.

## MAINTENANCE AND MANAGEMENT

Once spoil and topsoil storage areas have been established, they should require no maintenance unless catastrophic rainstorms denude the stockpiles of their vegetation. In this case, the piles will need to be reseeded.

## LABOR/MATERIALS

An end dump truck will be required to transport overburden material to an offsite storage location. Later, when the overburden (spoil, topsoil) is being replaced, a front-end loader will be needed to load the overburden on the dump trucks for transport back to the mine. The amount of labor and equipment time will vary significantly with such factors as the size of the operation, the amount of topsoil removed, and the distance to the storage location.

## SOURCES OF INFORMATION

Additional information and technical assistance can be requested from:

- State Regulatory Authority
- Office of Surface Mining
- Soil Conservation Service

References cited:

U.S. Forest Service. Research and demonstration of improved surface mining techniques in eastern Kentucky. Revegetation manual. Berea, KY: Report ARC-71-66-T4; 1975.

Additional references:

U.S. Forest Service. User guide to soils. Mining and reclamation in the West. Ogden, UT: Gen. Tech. Rpt. INT-68; 1979.

### c. Mycorrhizae and seed inoculum.

### PURPOSE

The structural association of living roots and fungi is called mycorrhiza. On some species, such as pines and beeches, fungi live on the outer root surface (ectomycorrhiza) while in others, such as orchids and heaths, the fungi invades the internal root structure (endomycorrhiza). This association aids the roots of the host plant in mineral uptake by providing a greater absorbing surface while the fungi obtains sugar from the host plant. This is a very significant mechanism of soil nutrient absorption in some plants (Jenny 1980). In many cases, timber production is dependent on mycorrhizal fungi since the growth and survival of many forest trees is dependent upon their presence (Maser et al. 1979).

Legumes must be inoculated with the proper bacteria before the seeds are planted. The bacteria are necessary to "fix" or provide nitrogen to the soil. Other bacteria contribute to the cycling of plant nutrients in the soil.

Bacteria and fungi are necessary for the decomposition of biological materials and the formation and improvement of the soil. The addition of these organisms is important to achieving productive soil. Often, in surface mining, the reclaimed areas consist of spoils from deeper geologic layers which may lack microorganisms. Natural inoculation and establishment of microorganisms in these spoils will eventually occur, but several factors can influence the rate and success of the inoculation. Among these are the spoil salinity, acidity, heavy metal content, nutrient levels, handling methods, and spoil storage time (U.S. Forest Service 1979).

### ILLUSTRATION

Microorganisms are reestablished in soils by natural processes, as well as artificial amendments. Several activities associated with surface mining tend to promote activity of fungi and bacteria. Since these organisms occur in topsoil, the replacement of natural topsoil material, where it is available, is a good method of reestablishing the site.

It is important to realize that microbial activity is greatly influenced by available oxygen and moisture (Alexander 1977); therefore, the storage of topsoil for long periods of time in deep narrow piles can reduce the functional capacity of these organisms (U.S. Forest Service 1979). Shallow, wide piles are preferable. Surface material (soil, litter, forest debris) from other sites may be placed on the mine spoil to introduce microorganisms to the site. There is some reinoculation of newly reclaimed sites by wind-blown dust from adjacent areas.

Soil amendments to adjust pH, salt, trace element, or nutrient problems may be necessary to promote revegetation. Generally, soil quality conducive to revegetation is also conducive to microbial activity. Mulching provides the carbon necessary for microbial activity while fertilizer amendments (e.g., nitrogen, phosphorus) that are necessary for successful revegetation will be adequate for microorganisms.

If there is an indication that poor revegetation success may be related to poor soil conditions (e.g., lack of mycorrhizal fungi, nitrogen-fixing bacteria), tests are available for determining the actual level of microbial soil activity. Direct species counts are prohibitive, but lab analysis for microbially related enzymatic activity in the soil can be accomplished by experts in the subject area. Biomass can be measured by ATP tests, viable counts, and even direct microscopic counts. These tests should be conducted at the advice and under the supervision of an expert and only when absolutely necessary.

Generally, the need for mycorrhizae is known to greenhouses and nurserymen so that seedlings are usually inoculated in the beds (Marx 1980). New equipment is being developed for applying mycorrhizae inoculum (U.S. Forest Service 1980) in nurseries. This equipment is in the final stages of testing so its utility in nurseries or on surface-mined lands is unknown. Dryland sodders and spriggers have been developed for transplanting topsoil and vegetation in clumps during reclamation (U.S. Forest Service 1980). These techniques have potential application for replacing natural microbial populations on mine spoils.

Donald Marx at the Southeastern Forest Experiment Station's Forestry Science Laboratory in Athens, Georgia, has done extensive work on ectomycorrhizae identification and inoculation techniques. Most of the work by the Forestry Science Laboratory so far has been with Pisolithus tinctorius. In addition, Abbott Laboratories, North Chicago, Illinois, has been studying ways of producing a dried, vermiculite-peat moss-based inoculum of P. tinctorius. Results indicate that Abbott Labs inoculum can form ectomycorrhizae on several species of pine, oak, spruce, Douglas fir, and hemlock. Other methods of inoculation include introducing duff, humus, infested soil, crushed sporophores, or excised mycorrhizal roots into the nursery soil or container-growing medium. Although these methods normally ensure ectomycorrhizal development, they also create problems. The inoculum may lack the most desirable fungi for the tree species and planting sites or can contain various harmful microorganisms and noxious weeds. In addition, sufficient quantities of sporophores or colonized roots may not be available when needed.

According to Aldon (personal communciation, May 12, 1981, Earl F. Aldon, U.S. Dept. Agric.-Forest Service, Rocky Mtn. Forest and Range Exp. Sta., 2205 Columbia S.E., Albuquerque, NM), the best method for incoulation of endomycorrhizae is to collect soil beneath a native stand of mature plants of the species to be planted. This soil should then be mixed with the soil in which the plants are placed. Although this is a tedious method, it is superior to waiting for the spores to blow in from somewhere else. Although aerial dispersion of spores does occur, the time period may be critical in ensuring better survival of transplants. If careful removal of the top few inches of topsoil would occur in the mining process, so that this soil would again be placed on top of a reclaimed area, enough mycorrhizal spores might be present to make inoculation unnecessary.

## MAINTENANCE AND MANAGEMENT

Prolonged storage of topsoil or prolonged wet or dry periods may reduce or inhibit the activity of microorganisms (mycorrhizae and bacteria) in the soil. Reinoculation of a site may be necessary for successful reclamation. The determination of such a need should be made by a soils expert.

Once mycorrhizal fungi and soil bacteria have been established, no maintenance should be necessary

## LABOR/MATERIALS

Materials for inoculation of mycorrhizal fungi do not cost anything if soil is taken from around plants that have mycorrhizae present. The labor costs would be high, however, because of the time involved to find the desired plants, collect the soil, and mix it with the planting medium for the new plants.

According to Dr. Donald Kenney of Abbott Labs (personal communication), *P. tinctorius* ectomycorrhizal inoculum is available commercially in small quantities in the southern U.S. on a test basis. The inoculum sells for $16 per liter which, when used with the injection planter developed by the USDA Forest Service, will inoculate approximately 750 seedlings.

## SOURCES OF INFORMATION

Additional information on the use of mycorrhizae can be obtained from:

Institute for Mycorrhizal Research and Development
U.S. Forest Service
Southeastern Forest Experiment Station
Athens, GA 30602

USDA, Soil Conservation Service
(Local office in phone book)

Dr. Donald Kenney
Abbot Laboratories
North Chicago
Chicago, IL 60064

References cited:

Alexander, M. Introduction to soil microbiology. New York: John Wiley and Sons; 1977.

Jenny, H. The soil resource origin and behavior. New York: Springer-Verlag; 1980.

Marx, D. H. Role of mycorrhizae in forestation of surface mines. Proc. trees for reclamation, Lexington, KY, October 27-28, 1980. Interstate Mining Compact Commission and U.S. Forest Service: 109-116; 1980.

Maser, C.; Anderson, R. G.; Cormack, K., Jr.; Williams, J. T.; Matin, R. E. Dead and down woody material. In: Ward, J. T. ed. Wildlife habitats in managed forests in the Blue Mountains of Oregon and Washington. Portland, OR: U.S. Forest Service, Agr. Handbook No. 553, Pacific Northwest Forest and Range Experiment Station; 1979:78-95.

U.S. Forest Service. Equipment development and test program 1979-80 progress and plans. U.S. Dept. of Agr.; September, 1980.

U.S. Forest Service. User guide to soils. Ogden, UT: U.S. Dept. Agr., General Tech. Rept. INT-68, Intmtn. Forest and Range Expt. Station; November, 1979.

### 3.2.2 Maintenance and Supplement to Food, Water, and Cover Resources

a. Buffer zones.

PURPOSE

Buffer zones are areas left unmined between the mining operation and areas designated for protection. The zone consists of a band of natural vegetation which "buffers" the effect of the mining activity (Figure 3.2-1).

Buffer zones may be used for a wide variety of purposes, such as:

- protecting critical habitat, such as the nesting site of threatened and endangered species
- protecting unique biological areas
- providing a visual screen (e.g., to hide a roadway)
- protecting streams or other water bodies from sedimentation

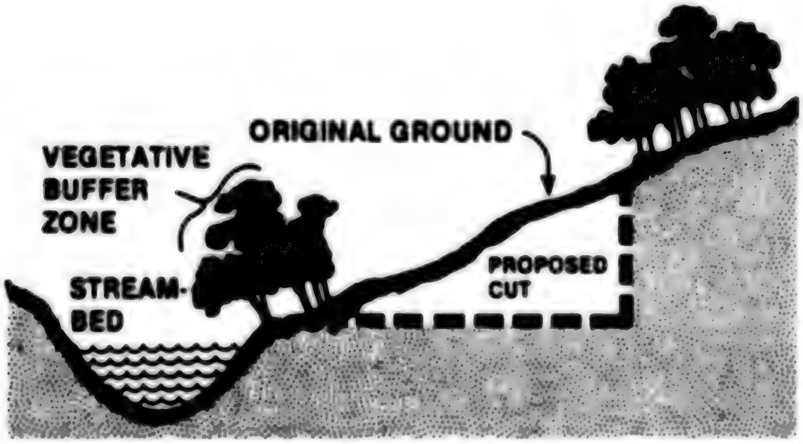


Figure 3.2-1. Vegetative buffer zones used to protect stream water quality (after U.S. Environmental Protection Agency 1976).

DEVELOPMENT

Several important factors should be considered in the utilization of buffer zones for purposes such as those outlined above. Site topography will often determine the size and configuration of the zone, while existing vegetation and type of mining practice will dictate the need for additional protective measures.

The protection of threatened and endangered species and critical habitats may require the establishment of a buffer zone. The size of the area, maintenance requirements, and management considerations should be determined in consultation with the U.S. Fish and Wildlife Service. State fish and game personnel can also provide assistance for protecting unique habitat or high value species as defined by a particular State. Consultation with a professional familiar with the local situation is often needed in the case of extremely unique or rare habitat and/or species. The actual need and configuration of the buffer zone can be difficult to determine because the life history of rare species is not often well known.

In general, haul and access roads should be designed to go around important wildlife use areas and should be hidden from the view of animals using the areas. The width of the buffer zone will vary with site conditions. A "rule of thumb" of 100 meters may be appropriate for the width of the zone (Stubbs and Markham 1979). This will help to protect wildlife from the noise, dust, and other disturbances related to road use.

The requirements related to development of buffer zones to protect streams are variable, depending on the regulatory authority. The width is established through consultation. These areas along streams are set aside for the main purpose of preventing erosion of streambanks and sedimentation of stream beds. In addition, they provide many of the habitat requirements for wildlife, such as protective cover for terrestrial animals, shading and cover for aquatic species, and areas for nesting and feeding. In essence, these zones provide a multifaceted contribution to the protection of fish, wildlife, and habitat.

## MAINTENANCE AND MANAGEMENT

Depending upon the regulatory authority, specific steps may have to be taken for delineating, marking, and maintaining stream buffer zones. In most cases, after these areas are set aside, they require little management.

## LABOR/MATERIALS

Labor costs depend a great deal on many of the factors already discussed. In a case where the area has to be surveyed and properly marked, the amount of labor depends on the size and configuration of the area. Survey costs on typical 4-hectare (10-acre) sites in central and southern Appalachia vary from $75 to $250, depending on local factors. Where wildlife enhancement is incorporated into the management of a buffer zone, the degree of effort and materials varies on a case-by-case basis.

## SOURCES OF INFORMATION

Although the State regulatory authority will ultimately determine the size and type of buffer zone required, the following agencies can provide additional assistance where wildlife protection and enhancement is a concern:

- U.S. Fish and Wildlife Service
- State Fish and Game Agencies
- Soil Conservation Service

References cited:

Stubbs, C. W.; Markham, B. J. Wildlife mitigative measures for oil and gas activity in Alberta. In: The mitigation symposium: A National workshop on mitigating losses of fish and wildlife habitats. General Tech. Rept. RM-65. G. Swanson, Tech. Coord. Rocky Mtn. For. and Range Expt. Sta., U.S. Dept. Agr., For. Serv.; July 16-20, 1979.

U.S. Environmental Protection Agency. Erosion and sediment control -Surface mining in the Eastern U.S. EPA Tech. Seminar Publ., EPA-625/3-76-006; 1976.

### b. Use of slash from clearing and grubbing.

PURPOSE

Woody debris left from a clearing or grubbing operation may represent valuable material for developing wildlife habitat. The material may be used for several purposes, such as:

- creation of cover and nesting habitat
- development of site barriers
- creation of temporary erosion control structures

Logs and downed woody material on the forest floor have often been viewed by forest managers as a fire hazard and objects that would attract forest pests that impede reforestation. However, these materials have real value that justify their salvage and incorporation into the reclamation plan. A few of the values include such factors as:

- Decaying woody material represents a reservoir of slowly released plant nutrients.
- Elevated areas on logs (e.g., knots, branches) serve as perches and feeding sites for wildlife.
- The decaying trunk provides grubs and other insects upon which woodpeckers feed.
- Root wads are used for dusting and nesting by several species of birds and small mammals.
- Spaces between the trunk and bark are used for escape and thermal cover by invertebrates and small vertebrates.
- Protected areas under a log are used for escape and thermal cover.
- Soft decayed wood is used by squirrels for food storage and by mice for burrows.
- The decaying log becomes colonized by ectomycorrhizal fungi which are necessary for establishment of certain trees.

These factors are discussed in detail, with suggestions applicable to a wide range of situations, in Thomas (1979).

ILLUSTRATION

## Logs

The decision to use slash debris depends to a large degree on the management objectives of the area. When land is used for wildlife habitat or timber production, the use of slash materials is a viable option for creating microhabitat on the reclaimed site.

The main value of logs is for cover and for feeding and reproduction sites. Several factors, however, need to be considered in the use of logs:

- A well-distributed pattern of logs provides the most variety of small animal habitat.
- A clumped, cluttered distribution of logs over an area will impede movement of large animals.
- Logs placed up- and downslope provide less valuable habitat than those placed along the contour. Orientation along the contour helps check erosion, while soil collected upslope provides a site for natural seedling establishment and provides an improved soil habitat (Ausmus 1977).
- The value of the log changes as its structure changes with decay. Logs serve as thermal cover and perches during the early stages of decay and as burrows and reproductive sites in the later stages.
- The size of the log influences its uses as habitat. Generally, larger logs provide more cover and can accommodate larger animals. Small-diameter logs (10 to 20 cm [4 to 8 inches]) are effective cover for small mammals, such as field mice and shrews, while larger logs can provide cover for animals the size of rabbits and opossums.
- The use of the log as habitat will depend on the composition of the plant community in which it is located, the successional stage, and the existing wildlife community.
- Fire-charred logs are less desirable because of the lack of bark and the difficulty that small animals and insects have in excavating charred material.
- Logs with cavities provide an extra attraction for cover and denning.

## Brushpiles

The smaller branches and woody material left after clearing and grubbing may be used to form brushpiles. This material can provide excellent cover for wildlife. The piled brush along powerline rights-of-way illustrates a good example of how such materials can be used to benefit wildlife. Research from right-of-way studies reveals that:

- Piles or windrows (long, narrow piles) are most effective if their length and width is less than 12 by 12 meters (40 by 40 feet). Long, narrow piles, less than 1.8 meters (6 feet) high, are best for general use.
- Piling downslope from depressions impedes soil erosion.
- Piles provide food and cover for wildlife, as well as humus to the soil (Hamrick and Bishop 1957; Ulrich 1976).
- Piling encourages burrowing animals (e.g., woodchuck), which, in turn, provides habitat for other species (Shomon et al. 1966).
- Upland game birds and rabbits benefit significantly from piles (Yoakum and Dasmann 1971). Game birds prefer loose piles.
- Rabbit habitat is readily improved by dense brushpiles (Kight 1971) 25 to 38 cm (10 to 15 inches) in diameter and 1.5 to 1.8 meters (5 to 6 feet) high.
- Turkey have been documented to use piles for nesting, especially around logs (Yoakum and Dasmann 1971).
- Ruffed grouse use loose piles for cover (Palmer and Ammann 1968).
- Piles are more effective along the edges of plant communities (e.g., forest-pasture border).
- Entanglement by grasses, vines, and forbs improve the habitat within the pile.

In addition to providing cover and food as brushpiles do, windrows may form effective screens. Piles may be used to form temporary breaks in the straight-line-of-sight on level topography until vegetative cover is established (U.S. Fish and Wildlife Service 1979).

## MAINTENANCE AND MANAGEMENT

The woody material which composes log and slash piles will decay with time and will need to be replaced, if desired, by the landowner. However, for all practical purposes, the piles will have fulfilled their usefulness by the time decay has significantly reduced the pile. As the reclaimed area around the pile becomes covered with vegetation of varying densities, many microhabitats will be created to replace those lost in the decaying piles.

## LABOR/MATERIALS

Cost, man-hours, equipment needs, and materials will vary with site-specific needs and characteristics. In wooded areas, slash material can be saved from the site-clearing activities and stockpiled. Equipment used in mining (e.g., dozers and dumptrucks) can then be used to move the slash when needed. The degree to which equipment is used, versus hand piling, will depend, in most cases, on site management activities (e.g., number of piles, size of piles, size of area). A brush pile in the 12 x 12 x 6 meter (40 x 40 x 6 feet) size range would take only 2 to 3 hours of equipment time, including loader and dumptruck. Handpiles would take 4 to 6 man hours.

## SOURCES OF INFORMATION

Information on use of slash materials may be obtained from:

- State Fish and Game Agency
- U.S. Forest Service
- U.S. Fish and Wildlife Service
- U.S. Soil Conservation Service - State Conservationist

References:

Ausmus, B. S. Regulation of wood decomposition rates by arthropod and annelid populations. In: Soil organisms as components of ecosystems. Proc. 6th Int. Soil Zod. Colloq. U. Lohm and T. Persson, eds. Ecol. Bull. [Stockholm] 25:180-192; 1977.

Hamrick, A. W.; Bishop, J. S. People, rights-of-way, and game. Proc. Conf. Northeast. Section Wildl. Soc; 1957.

Kight, J. Cottontail rabbit. In: How to have game on your land: Small game. Atlanta, GA: Ga. Game Fish Comm; 1971:25-28.

Palmer, W. L.; Ammann, G. A. Ruffed grouse and woodcock populations on several small study units of the Gratiot-Saginaw State Game Area. Mich. Dept. Conserv. Resour. Dev. Rept. 136; 1968.

Shomon, J. J.; Ashbaugh, B. L.; Tolman, C. D. Wildlife habitat improvement. New York, NY: Natl. Audubon Soc.; 1966.

Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. U.S. Forest Service, Agr. Handbook No. 553; 1979.

Ulrich, E. S. Selective clearing and maintenance of rights-of-way. In: R. Tillman, ed. Proceedings of the first National symposium on environmental concerns in rights-of-way management. State College, MS: Miss. State Univ.; 1976:206-219.

U.S. Fish and Wildlife Service. Management of transmission line rights-of-way for fish and wildlife. Volume 1. U.S. Dept. of Interior, FWS/OBS-79/22; 1979.

Yoakum, J.; Dasmann, W. P. Habitat manipulation practices. In: R. H. Giles, Jr., ed. Wildlife management techniques, 3rd ed. Wildl. Soc.; 1971:173-231.

### c. Rights-of-way management.

## PURPOSE

Rights-of-way (ROW) for roads and powerlines often involve large areas of land, which require continual maintenance. The primary purpose of powerline maintenance is to protect the lines from damage and to provide access. Along roadways, maintenance is directed toward improving visibility and removing roadside obstacles.

Maintenance of ROW's along actively used roads should discourage large animals from using the roadsides. High mortality of deer and other grazing animals occurs frequently along roads, where the animals are hit by vehicles. The benefits from providing more food or cover for these animals along well-used roads would, in the long run, be offset by introducing the possibility of injury or death.

ROW management along powerlines, however, should be promoted. Powerline corridors are often located in isolated areas, providing a place where animals can feed and rest undisturbed. In these areas, the wildlife manager can greatly improve wildlife habitat by appropriate initial cutting and/or replanting and periodic maintenance.

## DEVELOPMENT

A substantial amount of literature is currently being developed on powerline ROW management for wildlife (Tillman 1976; U.S. Department of Interior 1979a, 1979b, 1979c; Electric Power Research Institute 1981). The art of wildlife management along powerline ROW's is also well developed for many parts of the country. Because of the diverse requirements of wildlife species, the varying terrains in a region, and surrounding land uses, several techniques suitable for a region should be considered during ROW planning and management. The three volume publication, Management of Transmission Line Rights-of-Way for Fish and Wildlife (U.S. Department of Interior 1979a, 1979b, 1979c), is an excellent set of manuals, which should be consulted for this purpose. It lists numerous practices which have proven successful. Information on plant species which are suitable for ROW planting in many geographic areas are included. Several important considerations listed in this manual and other publications concerning wildlife habitat management along ROW's are listed below.

### Vegetation Management by Mechanical Means

- Clear-cutting and selective cutting techniques have been widely used to manage wildlife habitat in the Appalachians, but the specific effects of any cutting operation depend on the composition of the vegetation, topography, soil conditions, time of cut, and time since last cutting.

- Several studies suggest that selective cutting in Appalachian forested areas creates maximum wildlife diversity. Clumps of shrubs and small trees mixed with sparser vegetation, open grassy cover, and bare ground should be maintained where possible.

- Snags or den trees should be left when they pose no danger to the powerline. When clearing for the line, an occasional tree could be girdled and left standing rather than felled.

- "Hinge cutting" or the "cut-and-bend" method of cutting selected trees eventually produces a low, dense, living brushpile which provides ideal winter cover for small game. This technique involves cutting trees just deep enough so that the tops can be pushed over. The lower branches (no longer shaded) grow vigorously, while the connected tops grow upward again.

### Brushpiling

- In general, piling brush, rather than leaving it on the ground or removing it, provides cover for numerous small animals. Piling brush in natural depressions and gullies also retards erosion.

- Long, narrow brushpiles, less than 1.8 meters (6 feet) high, are preferable to higher rounded piles. They are also most effective when placed near the "edge" of other types of habitat.

  (Additional information in Section 3.2.2.b, Use of Slash from Clearing and Grubbing)

### Herbicide Application

- Herbicides are widely used in ROW maintenance and have recently been incorporated into wildlife management programs. Numerous types of herbicides are available for different purposes. Assistance from experienced wildlife managers should be obtained before using herbicides to alter wildlife habitat.

  (Additional information in Section 3.2.3.b, Pesticide and Herbicide Use)

### Planting and Seeding

- Wildlife management through planting and seeding has been practiced for many years in the mid-Atlantic and southeastern States. Rights-of-way which have become denuded through bulldozing or excessive cutting will need to be replanted to prevent erosion. This offers excellent opportunities to create valuable wildlife habitat through the use of proven wildlife plantings.

- Shrub and tree species planted along rights-of-way for wildlife include autumn olive, sericea lespedeza, several species of viburnum, silky dogwood, northern bayberry, and purple-osier willow. The berries of autumn olive are particularly attractive to songbirds, bobwhite quail, and ruffed grouse, while silky dogwood is cited as being intensively used by a wide variety of birds and mammals (Gordinier 1958). Seeding and planting information in Section 3.3 will aid in accomplishing the management objective and determining the specific plants useful for a particular site.

  (Additional information in Section 3.3, Practices or Reclamation Techniques Used to Enhance and/or Protect Fish and Wildlife Resources)

### Wetlands

- Avoiding wetland areas, where possible, will protect these valuable and fragile resources for wildlife use.
- In most cases, where the ROW impacts wetland areas, ROW management strategies should be to minimize the impacts rather than to manage the wetlands.
- During construction, avoid drainage ditches, spoil banks, or access roads that might restrict or prevent normal water movement.

## SOURCES OF INFORMATION

Additional information and technical assistance can be requested from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency
- U.S. Fish and Wildlife Service

References cited:

Electric Power Research Institute. Environmental concerns in right-of-way management. EPRI WS 78-141. Palo Alto, CA; 1981.

Gordinier, E. Establishing shrubby cover. Mich. Dep. Conserv. Rep. 2168; 1958.

Tillman, R., ed. Proceedings of the first national symposium on environmental concerns in right-of-way management. State College, MS: Miss. State Univ.; 1976.

U.S. Department of Interior. Management of transmission line rights-of-way of fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979a.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 2. Eastern United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979b.

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 3. Western United States. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979c.

### 3.2.3 Protection of Fish and Wildlife Resources during Mining

#### a. Wildfire control.

PURPOSE

A wildfire is defined as an "unplanned fire which requires suppression action, as contrasted with a prescribed fire burning within prepared lines enclosing a designated area under prescribed conditions" (U.S. Forest Service 1956). Prescribed burning has long been used as a wildlife management tool. It is one of the more economical procedures for removing a stand of vegetation.

Wildfires can result from improper or careless use of machinery or volatile materials, or from such a simple act as tossing a lighted cigarette on dry grass. Potential impacts on wildlife near the mine site from such an accident can be direct mortality and the temporary loss of many acres of valuable wildlife habitat on adjacent land. In addition, long-term degradation of the burned area, such as sheet erosion, can also occur as a result of improper fire-fighting methods.

DEVELOPMENT

Prevention of wildfires is by far the most desirable and economical way to avoid expensive fire-fighting and reclamation costs. Methods for prevention should include such things as:

- making sure all workmen are aware of the potential dangers of wildfire, particularly at worksites where the probability of occurrence is highest.
- posting a fire hazard alert whenever surrounding woodlands become extremely dry. This notice should be placed in an area frequented daily by workmen.
- placing fire extinguishers near or on all heavy machinery and at potential fire locations (e.g. storage sheds, lunch break locations, etc.).

Once a fire breaks out, the first and most important step in fire-fighting procedure is not to panic, but to assess the problem and take appropriate action. Initial actions could be, depending on the severity of the fire, either putting out the fire with available implements (e.g. fire extinguishers, buckets of water, shovels, etc.) or calling for assistance if nearby personnel cannot extinguish the blaze. Clear and decisive action during the early stages of a fire can mean the difference between a minor accident and a disaster.

If a fire has the potential for being uncontrollable, fire control lines can be installed with crawler tractors. Although fire control lines are excellent first-line defense for large wildfires, they have the disadvantage of promoting erosion after the fire unless preventive measures are taken. Usually, when lines are being built rapidly, little can be done to prevent erosion. However, if given the choice, good judgment with respect to line location, such as placing the line along the contour, will save time and effort in post-fire reclamation. Also, where a control line is being constructed near a slow-moving fire, diversion ditches could be installed, if necessary, as the line is being built. Diversion ditches will definitely be required on those control lines which cross the contour or drainageways.

Hot fires consume organic material from the soil surface, and subsequent rapid oxidation of the remaining organic matter bares the soil. This creates a situation very conducive to sheet erosion. After diversion ditches are in place, the area should be reclaimed by reseeding or replanting. Section 3.3 presents methods of establishing vegetative cover that will not only promote soil stabilization, but also benefit wildlife. Additional methods for preventing erosion on problem areas include the placement of logs or poles, tree tops, and/or stumps in actively eroding gullies.

## MAINTENANCE AND MANAGEMENT

Wildfire prevention is a continuing need. It is insurance against an accident which could potentially be devastating, not only in terms of loss of natural resources (i.e., timber, wildlife), but also in loss of property and human life. Fire prevention equipment should be periodically checked for readiness, and workmen should be reminded of the need for concern for wildfires.

## LABOR/MATERIALS

The number of fire extinguishers and other devices for fire protection needed will vary with the size of the mining operation and the particular needs at each site. The number of fire-fighters will also vary, depending on the severity and potential danger of the fire. In general, the final cost of stopping a wildfire will probably depend more on the speed with which it is extinguished, than any other factor.

## SOURCES OF INFORMATION

The following agencies welcome consultation on methods for preventing and fighting wildfires.

- U.S. Forest Service
- State Forest Agency

References cited:

U.S. Forest Service. Glossary of terms used in forest fire control. U.S. Dep. Agric. Handb. 104. Washington, D.C.; 1956.

Virginia State Water Control Board. Best management practices - forestry. Planning Bulletin 317. Roanoke, VA.; 1979.

### b. Pesticide and herbicide use.

### PURPOSE

Occasionally, it may be necessary to use pesticides or herbicides to control pests or weeds. These chemical agents are basically poisons and vary widely in toxicity and persistence. These compounds should be used with great caution and according to manufacturer's label and EPA and State criteria. On a reclamation site, pesticides are sometimes used to discourage birds and mammals from eating germinating seeds or browsing on tender shoots. Insect populations can also increase to the point where pesticides are required to prevent undue damage to vegetation. Herbicides, on the other hand, are less frequently used at mine sites. When they are used, they are usually applied along roadsides and around buildings to kill unwanted vegetation.

### DEVELOPMENT

When the mine operator has a problem requiring the use of either pesticides or herbicides, he should first contact the State surface mining regulatory authority for advice. There are many chemical agents available, and experts recommended by the State regulatory authority will be able to assist in determining the best control measures available.

Excessive applications and misuse are the most prevalent problems associated with pesticides and herbicides. On the premise that more of anything is better, the widespread tendency is to use an excess. When this happens, the end result is often the death of unintended species, the overkill of the intended species, undesirable toxic effects off site, or human contamination. It is important that personnel who are applying herbicides or pesticides follow the directions for use indicated for that specific chemical agent. Because of the potential danger from some pesticides, most States require that certain compounds may only be used by or under the supervision of a State Certified Pesticide Applicator.

### MAINTENANCE AND MANAGEMENT

Most herbicides currently in domestic use must be applied during the early growing season to be effective. Depending on the vegetation to be controlled, reapplication throughout the growing season may or may not be required.

Pesticide reuse is also highly dependent on several factors, such as the frequency and type of pest outbreaks, the toxicity and persistency of the pesticide, and the environmental conditions on site. For example, one application of a pesticide to young plants may be enough to protect them from caterpillar damage, while repeated applications of a rodenticide may be required to protect a young pine plantation from vole damage.

## LABOR/MATERIALS

The costs of using herbicides or pesticides will vary depending on the chemical used and the recommended rate of application. Cost estimates can be obtained by contacting a local agricultural products distributor.

## SOURCES OF INFORMATION

Additional information on the use of pesticides and herbicides can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Departments of Agriculture
- State Extension Service

Additional references:

U.S. Department of Interior. Management of transmission line rights-of-way for fish and wildlife. Volume 1. Background information. U.S. Fish and Wildlife Service. FWS/OBS-79/22; 1979.

Virginia State Water Control Board. Best management practices -forestry. Planning Bulletin 317. Roanoke, VA; 1979.

U.S. Forest Service. Wildlife habitat improvements handbook. FSH 2609.11; 1969.

### c. Drilled holes.

#### PURPOSE

Drill holes include exploration holes, boreholes, monitoring wells, or other exposed underground openings associated with the surface mining activity. These holes may be a planned part of the surface mining operation or uncovered during the operation. These holes can have direct impacts to wildlife, resulting in physical injury, while, at the same time, indirectly affecting habitat quality through surface water and/or ground water contamination.

Drill holes should be barricaded, fenced off, or protected until they are permanently sealed after abandonment or transferred to water well use. Some wells may be maintained for monitoring ground water quality.

#### ILLUSTRATION

Three major considerations need to be addressed: casing; protecting,; and sealing of wells or drill holes.

##### Casing

The main concern in casing drill holes is the protection of ground water. Toxic materials generated by the mining operation sometimes enter uncased wells. If ground water containing these materials surfaces in springs or streams, significant deterioration of wildlife and fish habitat could occur. Proper casing of wells would prevent such an occurrence.

Borehole wells can cave in and sometimes contaminate water aquifers. Casing pipe can be used to prevent such problems. Proper mining techniques in the drilling of wells has been described in several studies (Campbell and Lehr 1973; Moran et al. 1978; Anderson 1979).

Casing pipe varies in size, weight, and the ability to resist corrosion. Stainless steel and carbon steel are resistant to corrosion and are quite durable. Polyvinyl chloride (PVC) and epoxy reinforced by fiberglass do not have the strength of steel piping, but are useful in lengths of up to 61 meters and 91.4 meters (200 ft and 300 ft), respectively. Plastic casing is the cheapest and least durable of all piping, and is satisfactory for many casing uses. A disadvantage, however, is that plastic casing does not come in sizes larger than 15 cm (6 inches) in diameter. When installing any of these pipes, gravel or other inert packing material is used to fill in space around the casing. In addition, grouting with materials such as Portland cement, bentonite, perlite, Gilsonite, or diatomaceous earth is also necessary to seal the space around the casing to prevent surface contamination of the well and subsequent aquifer contamination (Barrett et al. 1980).

Drilling practices accepted by State or local standards should be adequate if followed. However, the State regulatory authority should be consulted for specific criteria which will meet their regulations and guidelines.

### Protecting

Drilling hole openings present a safety hazard not only to the human population, but also to wildlife. Fences can be used to exclude large animals and people from the area, while temporary caps can be used to seal the openings.

### Sealing

Permanent plugs may be used to seal openings. These must be water-tight in order to prevent water table contamination from surface drainage. The methods used must meet local health and safety standards.

## MAINTENANCE AND MANAGEMENT

In the case of barricades, temporary caps, and plugs, periodic checks need to be made to ensure continued protection of people and wildlife. After final plugging or sealing and approval by regulatory inspectors, maintenance is no longer required.

## LABOR/MATERIALS

Local well drilling companies can provide estimates of costs associated with casing and sealing wells or boreholes. In the central Appalachians, the cost for filling and sealing test holes and abandoned wells is approximately $650. If barricades or fencing are required, the additional expense will depend on the type and amount of fencing used. Fencing costs are discussed in Section 3.1.4 (Fences).

## SOURCES OF INFORMATION

Specifications and guidance on the requirements associated with the maintenance and management of drilled holes can be obtained from:

- State Regulatory Authority
- Office of Surface Mining

## References cited:

Anderson, K. E. Water well handbook. 4th Ed. Missouri Water Well and Pump Contractors Assocation; 1979. Bell, Missouri.

Barrett, J.; Deutsch, P. C.; Ethridge, F. G.; Franklin, W. T.; Heil, R. D.; McWhorter, D. B.; Youngberg, A. D. Procedures recommended for overburden and hydrologic studies of surface mines. Ogden, UT: U.S. Dept. Agr., For. Serv. Int. Forest and Range Expt. Station; 1980.

Campbell, M. D.; Lehr, J. H. Water well technology. New York: McGraw-Hill Book Co.; 1973.

Moran, S. R.; Groenewold, G. H.; Cherry, J. A. Geologic, hydrologic and geochemical concepts and techniques in overburden characterization for mined land reclamation. Rep. Invest. No. 63, North Dakota Geol. Surv.; 1978.

d. Dust control.

### PURPOSE

Fugitive dust can result from several activities associated with surface mining. These include, in order of intensity: (1) haul road usage; (2) dragline operation; (3) use of exposed areas; (4) front-end loader operation; (5) topsoil removal; (6) blasting; (7) dump truck traffic; (8) drilling; (9) shovel/truck loading; and (10) train loading (Moore and Mills 1978). Haul and access roads are by far the worst dust producers and need specific control measures developed into the mine plan to reduce the environmental impact.

Specific problems associated with fugitive dust vary, but include such items as:

- inhibited plant growth due to coating of leaves
- reduced palatability of vegetation to wildlife and domestic animals
- detrimental effects on mucous membranes of animals exposed to high levels of dust

### ILLUSTRATION

Dust may be controlled on haul and access roads by using water and/or chemical binders. Advantages and disadvantages of using either or a combination of these materials depend on several factors.

Watering, where there is a readily available source, is a common practice. Water is generally spread by such equipment as Wabco water trucks or Caterpillar 30,000- to 38,000-liter (8,000- to 10,000-gallon) spreaders. The number of water trucks needed depends on the length of roads to cover, as well as the drying conditions. Water is a very temporary retardant and, as such, has to be constantly applied at a rate that retards dust without creating hazardous, slick roads. Surfacing with gravel or "Red Dog," a chemical binder, will help reduce dust, as well as reduce the hazard of muddy roads.

Chemical binders may be used to provide longer-term dust control. These include such materials as polymer solutions, latex solutions, and asphalt emulsions. Although more expensive than water, the cost of these chemical binders must be weighed against very frequent watering and the cost of extra trucks in very dry situations, where dust is a major problem. Chemical binders can generally be applied with the same type of water truck, and the longer-term dust reduction, in turn, reduces the number of applications necessary. These chemical binders can also effectively be used to "tie down" topsoil or spoil storage piles to minimize wind-blown dust.

There is good evidence that road paving is a viable option in long-term operations. The purpose of paving, when it is done, however, is generally oriented toward improving the haul operation. Dust reduction, in this case, would be a significant added benefit (Chironis 1978).

## MAINTENANCE AND MANAGEMENT

The rate and frequency of application of control measures depends entirely on specific road conditions, such as roadbed material, number and size of trucks, length of road, the projected length of time of use of the road, and the type of material applied. In the case of chemicals, manufacturer's specifications will serve as a guide, but the real test is the amount of dust generated. Watering need only be frequent enough to keep the dust down, which will vary with temperature, relative humidity, and other factors.

Ripping of the road surface to a depth of an inch and application of dust retardant may be necessary to reduce rutting in chemically treated roads (Chironis 1978).

## LABOR/MATERIALS

Chemical binders may be purchased from regional distributors of asphalt and other road-building materials. A sample cost on a 21-meter (70-foot) wide haul road at a 15 percent dilution rate has been cited as $3,500 per mile, with annual upkeep at a dilution of 1:10 at about $2,000 per mile. These prices include the cost of the retardant only, which is about 11 cents per liter (Chironis 1978).

The number of trucks required for watering depends on the amount of road and the frequency of watering. Factors, such as distance from a suitable water source, enter into the costing.

## SOURCES OF INFORMATION

Additional information on dust control needs may be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- U.S. Forest Service
- State Highway Department

References cited:

Chironis, N. P., ed. Coal age operating handbook of coal surface mining and reclamation. New York: Vol. 2 - Coal Age Library of Operating Handbooks, McGraw-Hill, Inc.; 1978.

Moore, R.; Mills, T. An environmental guide to western surface mining. Part Two: Impacts, mitigation and monitoring. U.S. Fish and Wildlife Service, FWS/OBS-78/04; 1978.

e. Sediment ponds.

PURPOSE

Surface mining operations, like other large-scale earth-moving operations, have the potential to produce large amounts of sediment. If the sediment is contained on site, the problem is minimized; however, if it washes into adjacent waterways, it can become a serious pollutant. With respect to fish and wildlife, sediment can clog stream channels, act as a carrier for other pollutants (insecticides, herbicides, plant nutrients, etc.,), and fill lakes and ponds, resulting in degradation of aquatic habitats. In the Appalachians, acid drainage from mines can also be a serious problem which can significantly harm productive streams and lakes. Sediment ponds (Figure 3.2-2) are often the final line of defense in controlling these offsite environmental problems.

Sediment ponds are, by definition, holding areas at the periphery of a mine site to detain runoff for a short period of time and to trap heavier sediment particles. Regulations will vary from State to State with respect to the design criteria and number of sediment ponds needed on a particular type of site. In most States, an engineer is required to design these pond systems.

DEVELOPMENT

Basically, the sediment pond must be designed to accomplish two functions: (1) it must effectively remove a certain percentage of suspended sediment; and (2) it must provide sufficient storage capacity for the sediment removed from suspension. In order to accomplish these objectives, the location and number of ponds must first be determined. The ponds should be located to obtain maximum storage benefit from the terrain and for ease of cleanout of trapped sediment. Some agencies recommend that ponds be placed in the main drainway, while others prefer ponds placed out of main drainways to facilitate maintenance and removal. In some areas of the Appalachians, several small ponds may also be required, primarily because the topography is not suited to one large pond. Large ponds, however, have the advantage that they can often be designed to function for the life of a mine without cleaning.

Other design factors of sediment ponds to consider are the following:

- Spillways should consist of a principal and an emergency spillway. The combined capacities of both spillways should exceed the peak rate of runoff from a predetermined storm intensity.
- Points where surface runoff enter a sediment basin should be protected to prevent erosion. The point of exit from the pool should also be located as far as practical from the "point of entry." This will allow maximum settling time for particles in suspension to settle out before the water exits the basin.

- If sediment is to be removed from the pond, the mine plan should indicate the proposed method of removal. The sediment should not be placed in a location where it will eventually reach a stream. The mine plan should also outline the methods for removing or abandoning the sediment pond after mining is completed.
- The embankment should be formed from clean mineral soil, free of woody vegetation, large rocks, and other objectionable material. Pervious material, such as sand and gravel, should not be used.
- Immediately following construction, the embankment and spillways should be stabilized with vegetation approved by the regulatory authority.
- State and local laws must be met concerning fencing and posting of hazardous areas around the pond.

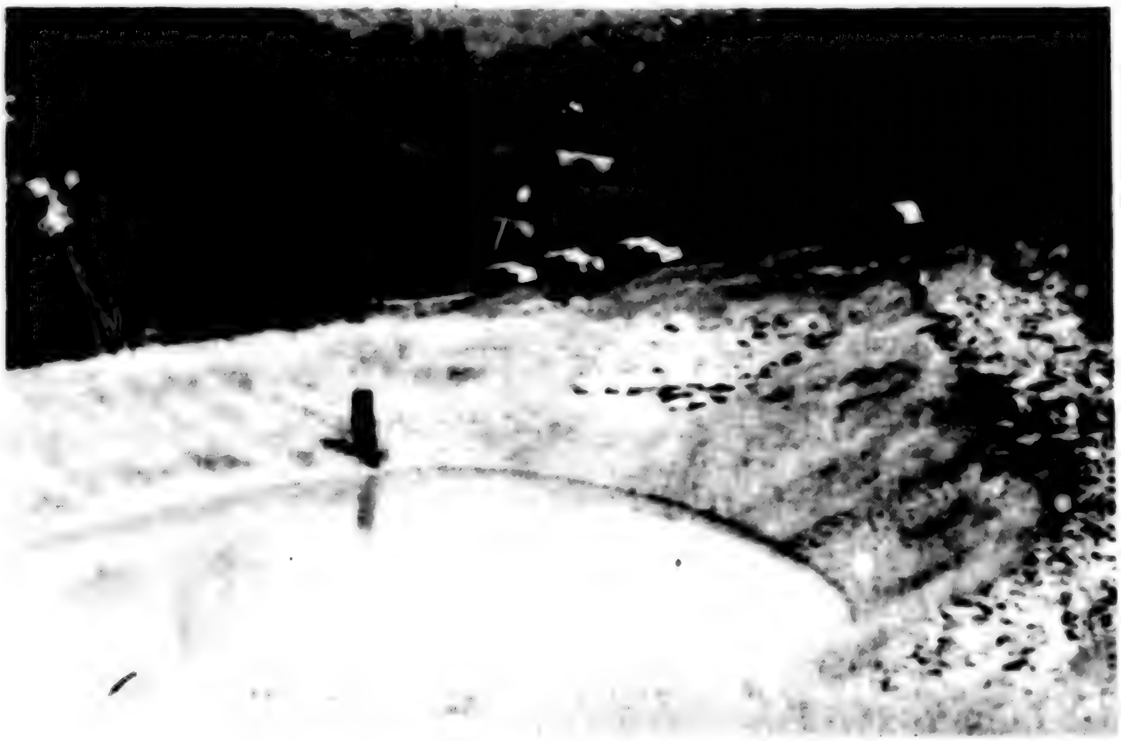


Figure 3.2-2. A well constructed sediment pond in the Appalachians (from U.S. Environmental Protection Agency 1976a).

Where possible, within current Federal and State regulations, and within specifications and construction design of sediment ponds, ponds may serve as sediment catchments and habitat or wildlife attractant areas.

Specifications and design criteria that may be included to construct sediment ponds more attractive to fish and wildlife include:

- For waterfowl areas, a combination of bank cover, feeding plants on shore and in shallow waters, and open swimming areas should be included.
- To maximize cover and edge effect of the sediment pond and adjacent terrestrial habitats, an irregularly shaped shoreline should be used.
- In larger ponds, sediment, along with other materials, may be used to build islands once the pond is no longer functioning as a sediment pond.
- Combinations of terrestrial and aquatic plants should be used to provide a diversity of cover and food sources.

Additional, more specific criteria are given in Sections 3.3.2.b and 3.3.2.h.

## MAINTENANCE AND MANAGEMENT

Sediment ponds should be checked frequently and routinely after high-intensity or major rainstorms. Corrective measures taken during the early stages of a problem, such as spillway stoppage or dam breaching, can help prevent costly repairs later.

Sediment must be removed from the pond when it reaches a predetermined depth below the top of the riser on the exit spillway. Many States have established criteria for sediment removal, but a rule of thumb is that a cleanout is required when the pond has reached 50% of its sediment storage capacity, or 6 months after the mining operation was started, whichever comes first (U.S. Environmental Protection Agency 1976a).

If the sediment pond is designed as a temporary structure, it can be disposed of after mining is completed and all disturbed areas are stabilized. If accumulated sediment is to be left in the pond, it should be covered with fill, topsoiled, compacted, and revegetated to prevent the sediment from leaving the site. If the sediment is to be disposed of on another location on the mine site, it should be spread in layers, dewatered, covered with earth, and revegetated. In situations where the embankment is built across a natural drainageway, the embankment and all accumulated sediment should be removed and the area returned to its original profile. Where the embankment is built adjacent to the natural drainage, the embankment, in some situations, can be left in place and the entrance channel diverted to the natural drainageway.

## LABOR/MATERIALS

The costs of sediment ponds can vary considerably, depending on the size of the mine site, the general terrain, and the number of ponds required. Generally, no more than 3-4 days of dozer time would be required per sediment pond and 1-2 days of end dump truck time to transport embankment material to the site.

## SOURCES OF INFORMATION

State surface mining regulations are specific with respect to the design criteria necessary for sediment ponds. Once these criteria are obtained, engineers can then design ponds which will meet the needs of specific mine sites. Additional information on ponds can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- Soil Conservation Service

References cited:

U.S. Environmental Protection Agency. Erosion and sediment control. Surface mining in the eastern U.S. Vol. 1 Planning. EPA-625/3-76-006; 1976a.

Additional references:

Grim, E. C.; Hill, R. D. Environmental protection in surface mining of coal. U.S. Environmental Protection Agency. Cincinnati, OH. EPA-670/2-74-093; 1974.

Soil Conservation Service. Engineering field manual for conservation practices. NTIS PB-244 668. Vols. I and II; April 1975.

Soil Conservation Service. Guide for sediment control on construction sites in North Carolina. Raleigh, NC; 1979.

U.S. Environmental Protection Agency. Erosion and sediment control. Surface mining in the eastern U.S. Vol. 2. Design. EPA-626/3-76-006; 1976b.

Virginia Division of Mined Land, Conservation, Reclamation. Reclamation manual. Coal surface mining. Richmond, VA; no date.

Virginia State Water Control Board. Best management practices handbook: surface mining (Draft). Richmond, VA; no date.

West Virginia Dept. of Natural Resour. Drainage handbook for surface mining. Charleston, WV: Div. Planning Develop. and Div. Reclam.; 1975 (Revised).

### f. Diversion ditches.

PURPOSE

Diversion ditches are a class of structures designed to intercept surface runoff and divert it to a safe disposal location. Typically, they are permanent or temporary structures constructed by digging a shallow ditch along a hillside and then building a soil dike along the downhill edge of the ditch with the removed soil. In most cases, permanent diversions are installed on long slopes of 15 percent or less which are subject to heavy runoff. They can also be used on abandoned haul roads as water bars to intercept runoff flowing down the roadway.

Diversion ditches can be of considerable value in preventing offsite siltation of waterways. Siltation of streams and lakes from surface mines can often be a serious problem, resulting in aquatic habitats being of marginal value to fish and wildlife. Erosion prevention in the form of diversion ditches, sediment ponds (Section 3.2.3.e), and stabilizing vegetation (Section 3.3) are, in many cases, essential to fish, wildlife, and environmental protection in the Appalachians.

DEVELOPMENT

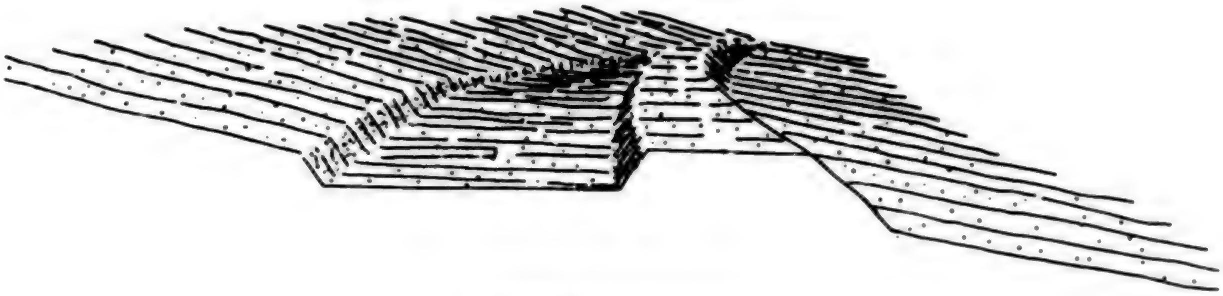
If diversion ditches are designed to be permanent on-site structures, they require certain design considerations. Standards and specifications for such structures should include the following:

- Location of ditches must consider outlet conditions, topography, land use, soil type, length of slope, seep planes, and mine layout.
- Construction specification requirements include:
  - The diversion to be constructed must meet the State's performance specifications.
  - The removal of all woody material and other objectionable material (i.e., large rocks, trash, etc.) from the ditch and dike.
  - The capacity and grade of the diversion, which will be specified by the regulatory authority.
  - The cross section of the channel should be either parabolic, V-shaped, or trapezoidal, as shown in Figure 3.2-3, with stable sides flat enough to insure ease of maintenance.

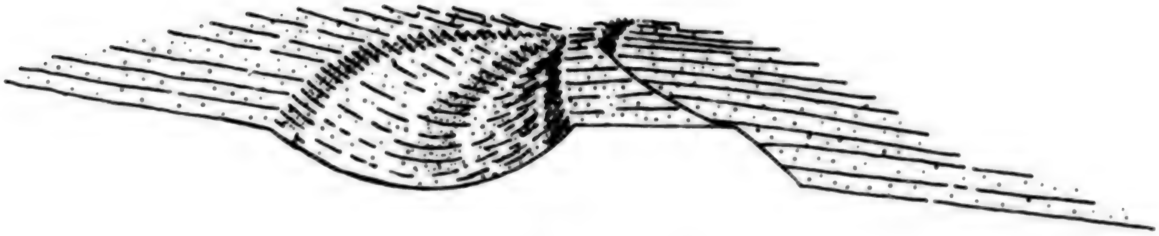
  - All excess earth not needed in construction should be placed so that it will not interfere with the functioning of the diversion.

- Vegetative stabilization should follow the State's standards and specifications for time of seeding, sprigging or sodding, liming and fertilizing, and site and seedbed preparation.

- Stone center diversions, as shown in Figure 3.2-4, or paved diversions should be considered in instances where heavy runoff is anticipated.



**Trapezoidal cross-section**



**Parabolic cross-section**

Figure 3.2-3. Effective cross-section shapes for diversion ditches (after U.S. Environmental Protection Agency 1976).

## MAINTENANCE AND MANAGEMENT

Ditches, like sediment ponds (Section 3.2.3.e), need to be checked routinely for accumulations of sediment, debris, and other obstructions that keep them from accomplishing their purpose. This is particularly important after heavy rainfalls, when there is the greatest possibility of blockage of runoff channels. Hillsides which have well-established vegetation will be less susceptible to diversion ditch failure, but nonetheless should be checked periodically during the bonding period.

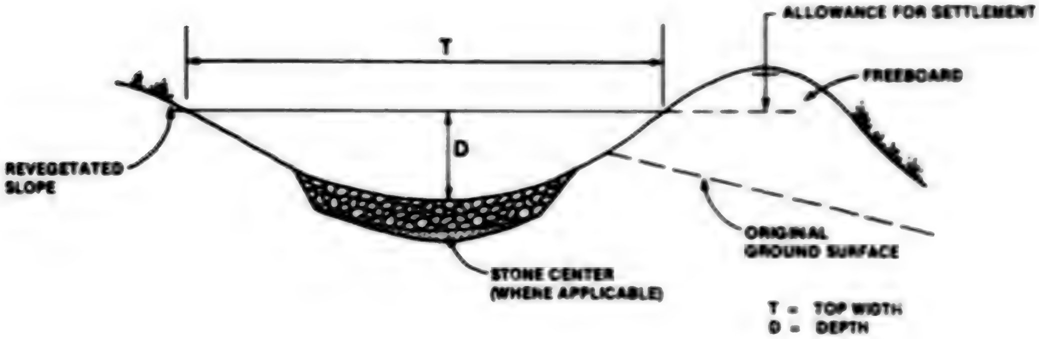


Figure 3.2-4. Stone center diversion for use in areas with heavy runoff (after Virginia State Water Control Board no date).

## LABOR AND MATERIALS

Once the slope has been graded to the required angle, diversion ditches can be installed with a minimum of personnel and equipment time. Subsequent compaction with roller graders will also require relatively little equipment time. Approximately 1 hour of equipment time would be required to construct and compact 305 linear meters (1,000 linear feet) of a typical parabolic-shaped ditch. An additional 6 to 8 man-days, in addition to the use of a dump truck, would be required to lay a stone center.

The cost for 5-cm (2-in) stone, suitable for laying a stone center in a diversion ditch, is currently $4.30 per ton. A ditch 61 meters (200 feet) long and 0.9 meters (one yard) wide, lined with 10 centimeters (4 inches) of stone, would require 5.4 cubic meters (7 cubic yard) or 9,080 kg (10 tons) of 5-cm (2-in) stone. Total cost for lining a ditch of this size would be $43.00.

## SOURCES OF INFORMATION

Additional assistance and technical information can be requested from:

- State Regulatory Authority
- Office of Surface Mining
- Soil Conservation Service

References cited:

Environmental Protection Agency. Erosion and sediment control. Surface mining in the eastern U.S. Vol. 2. Design. EPA-625/3-76-006; 1976.

Virginia State Water Control Board. Best management practices handbook. Surface mining (Draft). Richmond, VA; no date.

Additional references:

Environmental Protection Agency. Erosion and sediment control. Surface mining in the eastern U.S. Vol. 1. Planning. EPA-625/3-76-006; 1976.

Grim, E. C.; Hill, R. D. Environmental protection in surface mining of coal. Environmental Protection Agency. Cincinnati, Ohio. EPA-670/2-74-093; 1974.

Soil Conservation Service. Guide for sediment control on construction sites in North Carolina. Raleigh, NC; 1979.

Virginia Division of Mined Land, Conservation, Reclamation. Reclamation manual. Coal surface mining. Richmond, VA; no date.

### g. Access control.

PURPOSE

Access control may be necessary to protect critical wildlife areas which are opened up by mine support roads. Access is usually controlled by the mining companies as protection from theft, vandalism, and law suits due to injuries. New access to once remote areas has both advantages and disadvantages in terms of wildlife management. One advantage is that legal hunting and fishing activities may be expanded into once little-used areas, taking pressure off areas more frequently used. A disadvantage is that, along with legitimate resource utilization, illegal activities may put heavy pressure on a reserve of fish and wildlife that was formerly little utilized and unmanaged. These activities can create problems for the landowner, as well as the State game and fish management agency.

In addition to the direct effect of hunting pressures are the potential problems brought about by recreational vehicles. Noise, soil erosion, and wildfires, which are associated with uncontrolled off-road vehicle activities, can contribute to direct harassment of wildlife, as well as habitat destruction. It is important to remember that access roads associated with surface mines can lead to abuse if they are left open without any control. For example, while normal use may not be a problem, during times of high fire risk, strict control may be appropriate.

ILLUSTRATION

Access roadways can be closed with a locked gate to prevent casual traffic. "No hunting," "no trespassing," or "controlled access" signs can then be posted on the gate, indicating that the area behind the sign is off limits to unauthorized persons. The degree of access freedom may depend to a large degree on the desires of the landowner, who may coordinate recreational access with the mine operator.

The number of roads can be reduced significantly if companies operating adjacent or nearby mines can share road use. In addition, shared costs can result in cheaper operation with better roads.

MAINTENANCE AND MANAGEMENT

Periodic checks are necessary to ensure that the gate and signs are maintained. Also, the occurrence of illegal access should be ascertained, and, if security becomes a problem, patrols by fish and game agents or private security agents may be necessary. Consultation with local foresters to determine times of high fire risk and the need for tight control during these periods is an important consideration.

## LABOR/MATERIALS

The major costs are associated with the gate, gate posts, and installation costs. Security gate and post installation can run from $100 to $150, including approximately a half day for installation. If private security patrols are required, then labor costs are an additional item.

## SOURCES OF INFORMATION

Additional information on types of access control structures can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency

## 3.3 PRACTICES OR RECLAMATION TECHNIQUES USED TO ENHANCE AND/OR PROTECT FISH AND WILDLIFE RESOURCES

### 3.3.1 Revegetation

a. Seedbed preparation.

PURPOSE

Seedbed preparation, both mechanical and chemical, is necessary to ensure the timely establishment of vegetative cover. Mechanical preparation is generally limited to scarifying the soil surface immediately before seeding. Some postmining land uses may also require the removal of large rocks from the soil surface and immediate subsurface. Chemical preparation usually consists of liming to correct acid conditions (low pH) and fertilization to correct inadequate nutrient levels.

When seeding is performed immediately after final grading, mechanical preparation of the soil is usually not necessary. Also, seedings made during late winter to early spring in central and southern Appalachia are often successful without seedbed preparation due to loosening of the soil by frost action (U.S. Forest Service 1975). However, during other seasons, graded soils will crust over after a rain, thus requiring treatment before seeding.

DEVELOPMENT

Surface Preparation

When soil surface preparation is necessary, tilling or scarifying the soil can be performed by one of several methods. On areas that are not too steep (not over 20°) or rocky, tractor-drawn farm implements, such as a disc; bog harrow; spring-loaded chisel plow; or spring-tooth, spike-tooth, or flexible harrow can be used. Heavy-duty implements should be used since some breakage and excessive wear can be expected. For rougher, rockier areas, extra-heavy-duty equipment should be used, such as offset disc harrows and brush harrows designed to be drawn by crawler tractors. Preparation of extremely rough, rocky areas will require chisel plows or ripper teeth mounted behind a crawler tractor or grader. These implements leave a pronounced furrow and should be operated along the contour on slopes. Ripper teeth may also tend to drag large rocks to the surface where they may create a problem. Regrading with a bulldozer can also be used for seedbed preparation, but is generally much slower than drawing an implement and leaves a much poorer seedbed. Steep slopes are often limited to tracking-in with a bulldozer.

Regardless of the method of surface preparation used, the ultimate goal is to provide a firm seedbed with enough loose soil to insure seed coverage for germination. In central and southern Appalachia, bulldozers are often used to achieve seedbed preparation, especially on steep slopes. On steep slopes, the dozer tracks provide identations or small depressions that collect water and aid in seed germination. In the final grading, front-blading rather than back-blading allows for the tracks to be left on the seedbed. On moderate slopes and flats, conventional equipment can be used to prepare the desired seedbed.

## Treatment of Acid Soils

Reclaimed soils with low pH values are often encountered in central and southern Appalachia (Rafaill and Vogel 1978). Few plants can tolerate a pH of 4.0 or lower. While vegetation can be established at a pH level of 5.0-5.5, certain trace metals, such as aluminum and manganese, are soluble at this and lower levels. These metals are toxic to most plants, when soluble, and limit their survival and growth. By raising the pH value of the soil to a minimum of 5.5, these metals are rendered insoluble while plant nutrients become more available. Soil pH levels are raised by the application of agricultural limestone, hydrated lime, or rock phosphate.

Liming rates are best determined by testing soil samples. These tests can be performed by the State Testing Laboratory through a County Extension Agent. Private laboratories are also located in many of the coal fields. Liming rate recommendations from these tests normally specify the amount of lime required to neutralize the acidity in the top 6 inches of soil. After application, the lime should then be turned into the soil to a depth of 6 inches. Extremely acid soils that may slow revegetation should be limed at twice the recommended rate and turned to a depth of 12 inches. Turning of the lime into the soil can be accomplished during mechanical seedbed preparation, but the accepted agricultural practice is to apply lime 6 months before seeding. This allows the lime sufficient time to neutralize the acid, but requires scarifying the soil before seeding.

Agricultural limestone can be spread with a conventional lime-spreading truck in accessible areas. An Estes spreader or similar one-way blower mounted on a lime-spreading truck can be used to reach areas on steep slopes. Hydrated lime can be applied with a hydroseeder and has a higher neutralizing value than agricultural limestone. Rock phosphate, high in calcium and phosphorus, is applied in the same manner as agricultural limestone. Use of rock phosphate is best limited to marginal soils (pH 3.9-4.5), because it is not as effective as lime in neutralizing acidity, or where rock phosphate is considerably cheaper or easier to obtain than lime. Other materials that may be used to neutralize soil acidity include marl, calcium, silicate slag, and some types of fly ash. Technical advice should be obtained when these lime substitutes are considered for use.

## Correction of Nutrient Deficiencies

Most reclaimed soils are deficient in one or more of the major nutrients--nitrogen, phosphorus, and potassium--necessary for plant growth. In central and southern Appalachia, reclaimed soils are usually deficient in nitrogen and plant-available phosphorus (Rafaill and Vogel 1978). Potassium is seldom deficient.

Nutrient deficiencies can be corrected by the application of fertilizer in the form of ammonium nitrate, phosphoric acid, and potash. These compounds provide nitrogen (N), phosphorus (P), and potassium (K), respectively. These compounds can be obtained as a straight fertilizer which contains only one compound or as a mixed fertilizer which contains two or all three nutrients. Fertilizers are identified by percentage analysis of the three major nutrients. This percentage is always listed in the order N-P-K. An analysis of 0-46-0 indicates that this fertilizer, concentrated superphosphate, provides only phosphorus at a percentage of 46 percent by weight (100 kg [220 pounds] of fertilizer contains 46 kg [101 pounds] of phosphorus).

Likewise, a fertilizer with an analysis of 10-10-10 provides 10 kg (22 pounds) each of nitrogen, phosphorus, and potassium per 100 kg (220 pounds) of fertilizer. Minimum rates of fertilizer are required by State regulations. For example, Tennessee requires the following minimu rates be applied when regarding to the original contour: 45.4 kg (100 pounds) per 0.4 hectare (1 acre) each of nitrogen, phosphate, and potash. To ensure revegetation success. soil samples can be tested to determine whether the minimum requirements are sufficient. This is most important where phosphorus may be critically deficient.

Fertilizer can be applied at the same time seeding is performed or a few days before or after seeding. When seeding is done during winter when seeds are dormant, application of fertilizer should be delayed until the expected germination date in the spring.

Fertilizer can be applied by cyclone spreaders, tractor-drawn spreaders, lime trucks, or aircraft. Application of fertilizer with a hydroseeder is effective, but two problems may be encountered with this method. When mixed with water, fertilizer forms a salt solution that may damage seeds, especially grass seeds. Damage may occur if the seed-water-fertilizer slurry is allowed to stand for more than a few hours. The second problem arises when seeding legumes that require inoculating bacteria; the addition of fertilizer to the slurry lowers the pH (increases the acidity) of the mixture. A pH of 5.0 or lower can kill 75% of the inoculating bacteria within 2 hours. To maintain a viable inoculant, the following recommendations can be used:

- o Neutralize the acidity of the mixture by adding 45.4 kg (100 pounds) of hydrated lime for every 3,785 liters (1,000 gallons) of water. Add the inoculating bacteria at least 15 minutes after the hydrated lime has been added to the seed-water-fertilizer slurry.
- o Use larger amounts of inoculant; 1.5 to 2 times the recommended rate should prove effective.
- o A fresh supply of inoculating bacteria should be added if the seeding slurry is allowed to stand more than 2 hours.

## MAINTENANCE AND MANAGEMENT

Proper seedbed preparation greatly increases the chances of successful revegetation. If vegetation begins to fail during the bonding period, the affected areas should be checked for nutrient deficiencies or an acid condition. Refertilization and reliming may be necessary to correct these conditions.

## LABOR/MATERIALS

The amount of effort required to prepare a seedbed depends on site conditions, such as soil compaction, size and quantity of rocks, slope, and length of time since final grading. These conditions, in addition to the size of the area, will dictate what type of equipment and the number of hours of equipment time that will be required for tilling. On relatively level terrain, with most rocks removed, a tractor with a spike-tooth harrow can prepare an 8.1-hectare (20-acre) seedbed in an 8-hour day.

The application of soil amendments can be performed by a number of methods. A particularly rough area may require many man-hours of hand labor, but only one hour of aircraft time. Application costs vary, depending upon method and terrain. Combining the application of fertilizer with seeding by using a hydroseeder or dry-application blower can reduce costs considerably. A typical 14,000-16,000 kg (15-18 ton) limestone dry spreader with no special attachments will cost approximately $22,000. An optional attachment, a belt-over chain converter, which will allow seed and fertilizer spraying, will cost an additional $700. Costs for hydroseeders will vary from $17,000 for a 57,000 liter (15,000 gallon) capacity machine to $22,000-$25,000 for a 95,000 liter (25,000 gallon) capacity machine.

Material and labor costs for fertilization can be reduced by using fertilizers with high nutrient analyses. This reduces unnecessary handling of often unneeded bulk by allowing specific fertilizer requirements to be fulfilled.

## SOURCES OF INFORMATION

Additional information on seedbed preparation can be obtained from:

- State Regulatory Authority
- Soil Conservation Service
- State and County Extension Services

References cited:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; 1978.

U.S. Forest Service. Research and demonstration of improved surface mining techniques for the eastern Kentucky coal fields. ARC 71-66-T4: Appalachian Regional Commission; 1975.

Additional references:

Davis, H., ed. Specialized tools for final touches. *In*: Chironis, N. P., ed. Coal age operating handbook of coal surface mining and reclamation. New York: McGraw-Hill; 1978.

### b. Mulching.

#### PURPOSE

Mulching is the application of plant residues or other suitable materials to the soil surface. It is usually performed after a seeding operation to aid the establishment of vegetation. Mulching reduces erosion, conserves soil moisture, contributes organic matter to the soil, and reduces surface compaction or crusting of the soil. It is especially beneficial on sites with adverse growing conditions, such as dark-colored soils, south-facing slopes, highly erodible soils, and acid soils that have been limed.

#### DEVELOPMENT

There are many materials suitable for use as mulch, each with its own advantages and disadvantages. The most commonly used materials in the central and southern Appalachians are discussed below.

- Hay and straw are two of the better mulching materials, especially when they are anchored chemically or mechanically. Hay, composed mainly of grasses, often contains seeds that can also aid revegetation. Hay and straw should be applied at the rate of 1,400 kg per 0.4 hectare (1.5 tons per acre), either by hand or with a mulch blower.

- Most states have minimum requirements for mulching. Tennessee, for example, requires 1,816 kg (4,000 pounds) of straw or hay per 0.4 hectare (1 acre). The State regulatory authority should be contacted before plans are made to use different rates or materials from those specified in the regulations.

- Shredded bark is an excellent mulching material because it remains in place without tacking, even on steep slopes. Shredded bark can also be a source for introducing mycorrhizal fungi into the soil. Bark can be applied with an Estes or manure spreader at a rate of 34.4 cubic meter per 0.4 hectare (45 cubic yards per acre).

- Processed wood fibers and reprocessed paper materials can be mixed with seed and fertilizer for application by hydroseeder. High rates of application are necessary for effective erosion control, requiring a minimum of 681 kg per 0.4 hectare (1,500 pounds per acre).

- Leaves of deciduous trees are useful as a mulch and as an organic soil additive on level areas. This type of mulch is usually available only in the fall, unless collected and stored for later use. Leaves can be applied with a mulch blower or manure spreader at a rate of approximately 1,800 to 2,700 kg per 0.4 hectare (2 to 3 tons per acre), followed by light disking to hold them in place.

- Processed garbage and dewatered sewage sludge are also being used to a limited extent on some mine sites. Wide application of these mulches, however, is limited primarily because they are not readily available.

Most mulches require mechanical or chemical anchoring immediately after application to retard loss by wind or water. Mechanical anchoring can be accomplished with commercially available mulch nettings, a tractor-drawn mulch-anchoring tool, or by tracking-in with a crawler tractor. Chemical anchoring, or tacking, is performed by applying emulsified asphalt or a synthetic tacking agent. The emulsified asphalt is applied at a rate of 750 to 1,300 liters per 0.4 hectare (200 to 348 gallons per acre), depending on slope. Specifications for emulsified asphalt use are available from The Asphalt Institute (see Sources of Information). Commercially available synthetic tacking agents should be applied at the rates recommended by the manufacturers. Both emulsified asphalt and synthetic tacking agents are applied by spraying.

## MAINTENANCE AND MANAGEMENT

Mulched areas should be checked periodically, and places where the mulch has been removed by wind or water should be remulched until vegetation has stabilized the area. If mulch is physically mixed with the surface soil to prevent it from being removed from the site, precautions should be taken to prevent nitrogen depletion of the soil. In some instances, microbial action in the decomposition of the mulching material will cause some of the soil nitrogen to be bound up in other chemical compounds and be unusable to the growing vegetation. In these situations, where the mulching material is required to be mixed with the soil, the addition of extra nitrogen in the fertilizing mixture will help alleviate the problem of nitrogen depletion.

## LABOR/MATERIALS

Mulch material, application method, and anchoring requirements all determine the final cost per acre for mulching. Site conditions, availability of mulch, and compatibility of equipment for application are important considerations in selecting a mulch for efficiency in cost and performance. Mulch netting and synthetic tacking agents are usually used in small areas with special problems because of their cost. The average cost for mulch cover is $1,112.00 per hectare ($450.00 per acre), with an additional average cost of $2.09 per square meter ($2.50 per square yard) for erosion control matting.

## SOURCES OF INFORMATION

Additional information on mulching can be obtained from:

- State Regulatory Authority
- Soil Conservation Service

- State Department of Agriculture
- State Highway Department
- The Asphalt Institute
  Asphalt Institute Building
  College Park, MD 20740
  (301) 277-4258

References cited:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84. U.S. Fish and Wildlife Service; 1978.

Tennessee Department of Conservation. Regulations pertaining to surface mining. Division of Surface Mining and Reclamation; 1975.

The Asphalt Institute. Asphalt mulch treatment. Information Series No. 161; 1973.

The Asphalt Institute. Specification for paving and industrial asphalts. Specification Series No. 2; 1977 (revised biennially).

Virginia State Water Control Board. Best management practices handbook: Agriculture. Planning Bulletin 316. Richmond, VA; 1979.

Virginia State Water Control Board. Best management practices handbook: Forestry. Planning Bulletin 317. Richmond, VA; 1979.

### c. Direct seeding of trees and shrubs.

#### PURPOSE

Direct seeding is an effective method of establishing trees and shrubs for wildlife habitat on reclaimed areas. This method of establishing vegetative cover can be used in row-planting of woody species (Section 3.3.1.i, Planting Patterns) or in mixed-planting of woody and herbacaeous species to increase habitat diversity and provide food and cover.

At present, the number of woody species that have been successfully established by direct seeding in central and southern Appalachia is limited. Virginia pine, shortleaf pine, loblolly pine, black locust, bicolor lespedeza, indigobush, and green ash can be established by direct seeding (Rafaill and Vogel 1978). Other species, such as silky dogwood, bayberry, and autumn olive exhibit good potential. Several tree and shrub species are listed in Appendix C, along with their usefulness for wildlife. Many State and Federal agencies conduct tests for determining which woody species can be successfully seeded directly and can provide information on request about these species.

#### DEVELOPMENT

Planting schemes that call for rows or strips of woody vegetation can be hand-broadcast, drilled, or applied with a seed dribbler. Hand broadcasting requires a well-prepared seedbed and covering of the seeds after sowing. Hand broadcasting produces an uneven pattern of vegetation that is suitable for most plants, especially smaller shrubs.

A deep-furrow seed drill can be used to plant evenly spaced rows of plants. Most deep-furrow drills produce furrows 5 to 7.6 cm (2 to 3 inches) deep. The spacing of furrows can be adjusted, usually in increments of 31 cm (12 inches), to properly space the seeds according to plant species requirements. Most deep-furrow drills can be pulled by a farm tractor.

Seed dribblers, developed in the West, make use of the soil disturbed by the tracks of crawler tractors. Mounted in pairs, one over each track, the dribblers drop seed from a hopper onto each track as it rides over the front idler. Seeds fall from the tracks and are embedded in the soil by the tracks. Driven by a rubber-tired wheel riding against a track, seed dribblers can be adjusted for various seeds and seeding rates.

Area seeding of woody species can be performed with cyclone seeders, hydroseeders, and aircraft. Tree and shrub seeds can be seeded along with herbaceous species, but the herbaceous seeding should be reduced because competition from the faster-growing forbs and grasses may inhibit development of seedlings. Pines are especially sensitive to competition. To reduce competition, low-growing grasses and legumes should be used at seeding rates which will not produce too dense a stand. Recommended seeding rates for pure live seed (PLS) are listed in Table 1. The species listed should not be seeded at altitudes over 914 meters (3,000 feet) in the northern sections of central Appalachia.

Table 3.3-1. Pure live seed seeding rates for selected woody species (from Rafaill and Vogel 1978).

| Species | kg/hectare | (lb/acre) |
|---|---|---|
| Black locust | 2.5-3.75 | (2-3) |
| Bicolor lespedeza | 1.25-2.5 | (1-2) |
| Indigobush (pods) | 0.6 | (0.5) |
| Shortleaf pine | 0.6-1.25 | (0.5-1) |
| Virginia pine | 0.3-0.6 | (0.25-0.5) |
| Green ash | 2.5 | (2) |

Direct seeding should be performed during late fall, late winter, or early spring.

## MAINTENANCE AND MANAGEMENT

Clearing a small area around each seedling during the first two or three growing seasons would greatly increase seedling survival, but may be impractical on large areas. This treatment would be feasible for strip and row plantings. Reseeding of woody species is not recommended in areas with established herbaceous cover.

## LABOR/MATERIALS

Direct seeding of trees and shrubs can be very economical. A study comparing the costs of direct seeding versus transplanting of shrubs shows a significant cost difference (Crofts and Parkin 1979). The cost of each shrub established from direct seeding ranged from $0.001 to $0.031 per plant, where the cost of transplanted shrubs averaged $9.89 per plant.

Seed can be hand-broadcast at a rate of 3 hectares (8 acres) per man-day when seeding at a rate of 15 kg/hr (12 pounds/hr) of seed (Rafaill and Vogel 1978).

## SOURCES OF INFORMATION

Additional information on direct seeding of trees and shrubs can be obtained from:

- U.S. Forest Service
- Soil Conservation Service
- State Forestry Commission
- State Agricultural Research Stations

References cited:

Crofts, K. A.; Parkin, C. A. Methods of shrubs and tree establishment on strip mined lands in northwest Colorado. In: Symposium on surface coal mining and reclamation. Coal Conference and Expo V; 1979, October 23-25; Louisville, KY: McGraw-Hill, New York; 1979.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84. U.S. Fish and Wildlife Service; 1978.

Additional references:

Larson, J. E. Revegetation equipment catalog. Washington, DC: U.S. Forest Service; 1980.

Plass, W. T. Preliminary recommendations for seeding pine on surface mine spoils. Charleston, WV: Green Lands 5(1); 1975.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH2609.11: Washington, DC; 1969.

Zarger, T. G.; Curry, J. A.; Allen, J. C. Seeding of pine in coal spoil banks in the Tennessee Valley. In: Hatnik, R. J.; Davis, G., eds. Ecology and reclamation of devastated land. New York: Gordon and Breach; 1973.

### d. Planting of tree and shrub seedlings.

#### PURPOSE

Planting of tree and shrub seedlings and wildlings for wildlife allows more control of planting density and species composition than direct seeding (Section 3.3.1.c, Direct Seeding of Trees and Shrubs) and decreases the time necessary to establish woody vegetation.

#### DEVELOPMENT

##### Planting Methods

Both hand- and machine-planting methods can be used to plant seedlings. Hand planting is necessary on steep slopes and is more cost-effective for small areas than machine planting. Tractor-drawn planting machines are used on large, level to gently sloping areas that are free of stones. The maximum safe slope for planting on the contour with a machine is 20% (Virginia State Water Control Board 1978). Slopes of up to 25% can be planted up- and downslope.

Seedlings can be planted by hand by using a mattock or planting bar. Planting bars (dibbles) are usually easier and faster to use for most seedlings. Seedlings with spreading root systems may require the use of a mattock to provide a planting hole of adequate size. Planting holes for all seedlings must be large enough to allow the roots to spread out without being crooked or doubled under.

For either planting method, the soil should be packed firmly around the root system. When planting by machine, it is wise to have someone on foot follow the machine to reset any loose seedlings.

##### Planting Period

In central and southern Appalachia, seedlings can be planted from December through April (Rafaill and Vogel 1978) but, on sites with severe exposure, planting should be deferred until spring. Frost heaving may be a problem during the winter in some soils.

##### Planting Densities

State regulations require the successful establishment of a certain number of stems per 0.4 hectare (1 acre). The State regulatory authority must be consulted for the number of seedlings required, which will often vary with the postmining land use. Expected survival rates of seedlings can be determined so that a sufficient number of seedlings can be planted to allow for loss. Table 3.3-2 lists the number of seedlings per 0.4 hectare (1 acre) when planted on different spacings.

Table 3.3-2. Seedlings per 0.4 hectare (1 acre) at various spacing distances.

| Spacing [meters (feet)] | Seedlings per 0.4 hectare (1 acre) |
|---|---|
| 1.8 x 1.8 (6 x 6) | 1200 |
| 1.8 x 2.1 (6 x 7) | 1037 |
| 1.8 x 2.4 (6 x 8) | 907 |
| 2.1 x 2.1 (7 x 7) | 890 |
| 2.4 x 2.4 (8 x 8) | 680 |

### Handling of Planting Stock

Most tree and shrub planting stock used for reclamation in central and southern Appalachia is bare-root stock. Seedlings that cannot be planted within two weeks after delivery should be heeled-in and kept moist until they can be planted. Drying of the roots can kill seedlings in a very short time.

## MAINTENANCE AND MANAGEMENT

Although clearing around each seedling can increase the survival rate of a planting in areas with dense herbaceous cover, competition from herbaceous species is often a limiting factor in establishing woody vegetation, especially conifers. Unfortunately, additional fertilization has proven to be of little value in helping establish woody species. Uncontrolled grazing of revegetated areas should not be permitted until the plants are well-established--usually the third or fourth growing season.

## LABOR/MATERIALS

Seedlings can be planted by hand at a normal rate of 500 to 800 seedlings per man-day. Tractor-drawn seedling planters can plant about 5,000 seedlings per day.

Bare-root stock tree seedlings are available from State and private nurseries. Commonly used species, such as black locust, loblolly pine, Virginia pine, and shortleaf pine, cost about $10.00 per 500 seedlings.

## SOURCES OF INFORMATION

Additional information on the planting of tree and shrub seedlings can be obtained from:

- State Regulatory Authority
- State Forester
- State Forest Extension Service
- U.S. Forest Service
- Soil Conservation Service
- Tennessee Valley Authority

References cited:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. FWS/OBS-78/84. Washington, DC: U.S. Fish and Wildlife Service; 1978.

Virginia State Water Control Board. Best management practices handbook--surface mining. Draft Planning Bulletin. Richmond; 1978.

Additional references:

Fowler, D. K; Adkisson, L. F. Survival and growth of wildlife shrubs and trees on acid mine soil. Technical Note B37. Norris, TN: Tennessee Valley Authority; 1980.

### e. Vegetation clump transplanting system.

PURPOSE

Transplanting of native vegetation (trees, shrubs, and other species) can provide mature growing plants immediately to the reclaimed area and create a nucleus from which seeds and other organisms can re-invade the area. Other advantages include immediate cover for wildlife, erosion control, and improved landscape aesthetics. This system, as described below, is more effective and efficient than current mechanized transplanting systems and compares favorably in cost with reseeding or planting of nursery stock. It also has wide geographic adaptability because it can be used in virtually any location where the machinery can be transported.

ILLUSTRATION

The transplant system consists of a front-end loader (FEL) and a transporter. The FEL bucket should be designed to maximize the area of material (soil plus vegetation) that can be removed. Because of operating costs and production efficiency, the FEL should be used only for removing clumps of vegetation from undisturbed soil and transferring them short distances. If the distance which an FEL has to move is greater than 274 meters (300 yards), or if there is limited availability of the FEL, a separate transporter makes the operation more efficient. The transporter currently modified for this use is a Hesston stack mover (see Labor/Materials section). In the transplanting operation, the transporter is used to pick up clumps of vegetation removed by an FEL and transport the clumps either to a holding area or to the transplant site.

The operation of the FEL bucket for transplanting, which differs markedly from typical FEL operation, is as follows:

1. A vertical bank or step, approximately 0.6 meter (2 feet high), is cut around the source of trees and shrubs.
2. With the bucket bottom parallel to the ground surface and between 0.3 and 0.6 meter (1 to 2 feet) below the top of the vertical bank, the bucket is pushed into the bank.
3. When the bucket is full, it is lifted vertically, thereby removing a clump of vegetation and soil.
4. The bucket is tilted back (towards the loader) about 10° to 15°, and the clump is transported by the loader to a nearby location.
5. At the unloading point, the bucket is tilted forward (30° to 45° or more) and the loader is reversed, leaving the clump on the ground.

6. The loader is returned to the source of vegetation and the cycle is repeated. Any access roads that may be required for unloading are constructed prior to picking up the next clump, and any necessary surface leveling is done. All roadbuilding and leveling operations must be done with the reclamation bucket.

At this point, if a transporter is utilized, it should have the following characteristics:

1. Capable of picking up clumps of vegetation, each having an area of 6.97 square hectares (75 square feet), and including small trees.
2. Capable of transporting vegetation loads in excess of 13.9 square meters (150 square feet) per load at speeds up to 32 kilometers (20 miles) per hour.
3. Capable of placing the vegetation clumps in the transplant area.

## MAINTENANCE AND MANAGEMENT

As a conventional piece of mine production equipment, the FEL would be readily available, but, as mentioned earlier, should only be used to transport clumps of vegetation short distances. This would tend to maximize the efficiency of the FEL, compared to the higher operating costs that would be incurred if the FEL had to transport vegetation long distances. The use of a separate transporter would enable large areas to be transplanted in less time than with an FEL alone. Maintenance of equipment, such as FEL's and transporters, is standard practice during mining operations.

## LABOR/MATERIALS

Specifications for equipment are as follows:

### Reclamation Bucket

1. Recommended bucket size is 4.6 meters (15 feet) wide, 1.5 meters (5 feet) deep, and 0.9 meter (3 feet) high.
2. Lucite is used to line the inside bottom of the reclamation bucket. This material proved superior in field tests and will significantly reduce the sticking problem and problems of soil freezing to the bucket.

3. The front cutting edge of the reclamation bucket should be straight and balanced (the cutting edge will have an equal angle and length bevel on top and bottom). This will help control the depth of cutting and help confine soil in the clump.

## Transporter

The modified Hesston stack mover, presently being used for transporting operations, was originally manufactured to load, transport, and unload haystacks. It consists of the following mechanical elements:

1. A tilt-bed trailer having a surface area of approximately 15.8 square meters (170 square feet).
2. A chain conveying system capable of sliding the stack across the top of the trailer.
3. A pickup roller for separating the stack from the ground.
4. A set of tracks located at the rear of the trailer to pull the trailer under the stacks.

The rear tracks are synchronized with the conveyer so that the stack is pulled up into the trailer at the same rate that the tracks pull the trailer under the stack. When unloading, the stack is moved off the trailer at the same rate that the rear tracks push the trailer forward. The maximum tilt angle of the trailer is approximately 15° (about 20 percent of the angle used between the FEL transplant bucket and the ground surface when unloading). When the clumps of vegetation are handled by the transporter, they are subjected to minimal bending.

The stack mover was converted to a vegetation transporter by the following modifications:

1. The subframe and tilt bed were strengthened for increased load-carrying capability.
2. The pickup roller was removed, and a short incline was located on the tail of the trailer to slide the vegetation clumps up on the conveyor chain.
3. The tilt-bed trailer was covered with Lucite to reduce friction and facilitate moving vegetation clumps across the top of the trailer.
4. Because a self-contained hydraulic system was mounted on the trailer, only a prime mover (truck or farm tractor) was required for operation of the transporter.

It should be noted that, although the converted stack mover is narrower than the transplant bucket (2.7 meters compared to 4.6 meters [9 feet compared to 15 feet]), it will be possible to move clumps having the full 1.5-meter (5-foot) lateral dimension of the transplant bucket. This is the critical dimension because it represents the length over which the clumps are subjected to bending as they are moved on and off the transporter.

## SOURCES OF INFORMATION

The U.S. Bureau of Mines, Spokane, Washington, is currently funding a study to evaluate transplanting native vegetation and the mobile transporter system. The prime contractor for the field test is Colorado State University, Fort Collins, Colorado. Energy Fuels Corporation is the cost-sharing cooperator providing senior staff, machinery, equipment, and facilities.

References cited:

Frizzel, E. M.; Smith, J. L.; Crofts, K. A. Transplanting native vegetation. In: Surface coal mining reclamation equipment and techniques. U.S. Bureau of Mines Information Circular 8823; 1980: 48-53.

### f. Nurse crops and preparatory crops.

## PURPOSE

The purpose of nurse and preparatory crops is to provide rapid stabilization of the site and to provide for site modification in favor of establishing permanent cover. Even though their functions are similar, there are important differences in the two crop systems. A preparatory crop is one that is sown and harvested prior to the permanent crop. The permanent crop is then seeded directly into the stubble of the preparatory crop. On the other hand, a nurse crop is seeded with the permanent crop. Nurse crop species are generally annual, quick-cover species that are mixed with the more permanent perennials. The nurse crop is quickly established, thus providing suitable habitat modification for the target species. Nurse crops are sometimes called cover crops or companion crops (green mulch).

Nurse and preparatory crops are not always required for a successful reclamation program. Advantages or disadvantages depend on reclamation objectives and site-specific factors. Benefits may include the addition of organic matter to the soil, moderating soil surface temperatures, and modifying effects due to winds. Oftentimes, the nurse or preparatory crop also furnishes high quality forage and seed crops useful to wildlife. Some of the major considerations are discussed below.

## RECOMMENDATIONS

Since erosion control is a high priority objective on slopes in central and southern Appalachia, seeding mixtures which are used contain a mix of at least one annual grass and one perennial legume species. The annual grass provides quick cover while the legume provides long-term cover and a source of nitrogen. Some annuals reseed themselves (e.g., Kobe and Korean lespedeza), while others (e.g., oats, wheat, rye) only provide adequate cover for a single season. Biennials (e.g., red and sweet clover) last two seasons, while perennials (e.g., Indiangrass, switchgrass, bluestem) last three seasons or more (Rafaill and Vogel 1978).

There are several advantages to the use of nurse or preparatory crops. Nurse crops tend to reduce wind and water erosion and reduce the germination of weed species that compete with the permanent cover. Nurse crops, such as oats and wheat, may also be harvested for a return on investment prior to the establishment of permanent cover. Seeds harvested from a preparatory crop of wheat have been used to reseed newly reclaimed areas in southeast Kentucky (personal communication, Jim Davis, July 15, 1980, Mecklen Berg Coal and Mining Incorporated, P.O. Box 246, Ferguson, KY). Preparatory crops also protect the soil from wind and water erosion, while the stubble reduces water loss, thus aiding the establishment of permanent species. As an added benefit, weed growth is reduced by competition from the preparatory crop.

A disadvantage of nurse crops is that they compete with the desired permanent species for moisture. Preparatory crops leave a thick residue that can inhibit seed germination of the permanent species. Second-year germinating seeds of the preparatory crop will compete with the permanent cover. In a few cases, residue from the preparatory crop may contain substances toxic to the permanent cover. These disadvantages can be reduced, to some extent, by reducing the seeding rate of the nurse crop species.

In general, nurse crops are not recommended in areas with limited moisture availability due to competition for water. Irrigation may be required for successful establishment in such a case. Preparatory crops have a greater benefit on dry sites, where the reduction in surface temperature and water loss is promoted by the stubble (U.S. Forest Service 1979).

## MAINTENANCE AND MANAGEMENT

Preparatory crops should be mowed before they seed in order to prevent competition with the target perennial species.

Where the vegetation fails or cover is poor, replanting, refertilizing, and/or reliming may be necessary. Once perennial legumes are established, refertilization of established vegetation is usually not necessary. Grazing, where it is allowed, has to be controlled. Grazing will damage most cover vegetation if the cover has not been established for at least 2 years; a 3- to 4-year interval of "no grazing" is preferable (Rafaill and Vogel 1978). Overgrazing destroys the vegetation cover, reducing its value to wildlife; continued monitoring of grazing is necessary to prevent this from occurring.

## LABOR/MATERIALS

Seeding costs for the nurse crop will vary with seed mixture used and local conditions. Generally, a mixture of annual grasses, annual legumes, and grain crops can run approximately $124/hectare ($50/acre) for seed mixtures. Added to that is $54/hectare ($22/acre) for seedbed preparation, $15/hectare ($6.00/acre) for seeding, and $99/hectare ($40/acre) for soil amendments.

## SOURCES OF INFORMATION

Additional information on the use of nurse crops and preparatory crops can be obtained from:

- State Regulatory Authority
- Soil Conservation Service
- State Fish and Game Agency

References cited:

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service, FWS/OBS-78/84; July, 1978.

U.S. Forest Service. User guide to vegetation. Ogden, UT: Forest Service Tech. Rept. INT-64, Intmtn. Forest and Range Expt. Sta.; 1979.

### g. Stabilization of critical areas with fabric netting.

PURPOSE

Fabric netting is a coarse, open-mesh material woven of natural or synthetic fibers that is used as a mechanical aid to reduce erosion of critical areas during the time necessary to establish vegetative cover. A critical area may be a very steep bank, a diversion ditch, a surface with highly erodible soil, or other area that presents erosion or stabilization problems. Used in place of mulch (Section 3.3.1.b, Mulching), fabric netting provides exceptional protection against wind and water erosion. It often reduces siltation to streams by reducing the sediment entering sediment ponds and lowering suspended solids leaving the ponds.

DEVELOPMENT (Virginia State Water Control Board 1978)

Fabric netting must make full contact with the soil surface to be effective. After final shaping or grading of an area, all rocks and clods larger than 3.8 cm (1.5 inches) in diameter must be removed. Sticks and other materials that could prevent the netting from contacting the surface must also be removed.

Liming, fertilizing (Section 3.3.1.a, Seedbed Preparation), and seeding should be performed before placing the netting. If desired, half of the required amount of seed can be applied before the netting is placed and the other half after the netting is down. This may help prevent seed loss if there is a delay between seeding and placing of the netting.

Fabric netting is supplied in rolls. The netting is placed at the top of the slope and is unrolled downgrade. The top edge of the netting is buried in a narrow trench that is 10 cm (4 inches) or more deep (Figure 3.3-1). The filled trench should be well-tamped and the edge secured with a row of U-staples about 10 cm (4 inches) downhill from the trench. These staples should be spaced about 25 cm (10 inches) apart. Outside edges are stapled 0.9 to 1.2 meters (3 to 4 feet) apart.

Where more than one roll is necessary to cover an area, a 5-cm (2-inch) overlap is allowed along the outside edges of each roll. The overlapped netting is then stapled to the ground together. When netting ends are joined to extend the netting down the slope, a 10-cm (4-inch) overlap is allowed and buried in a trench. Again, staples are placed along the overlap at 25-cm (10-inch) intervals. After securing the netting, use a roller at a right angle to the slope to ensure good contact between the soil and netting. Perfect contact is essential for the netting to be effective.

For added effectiveness, erosion stops may be made at any place along the length of the netting. Erosion stops check water flow and erosion that may occur underneath the netting. A 10-cm (4-inch) fold is made in the netting, buried, and secured with a double row of staples. Erosion stops can be spaced from 7.6 to 30.5 m (25 to 100 feet) apart.

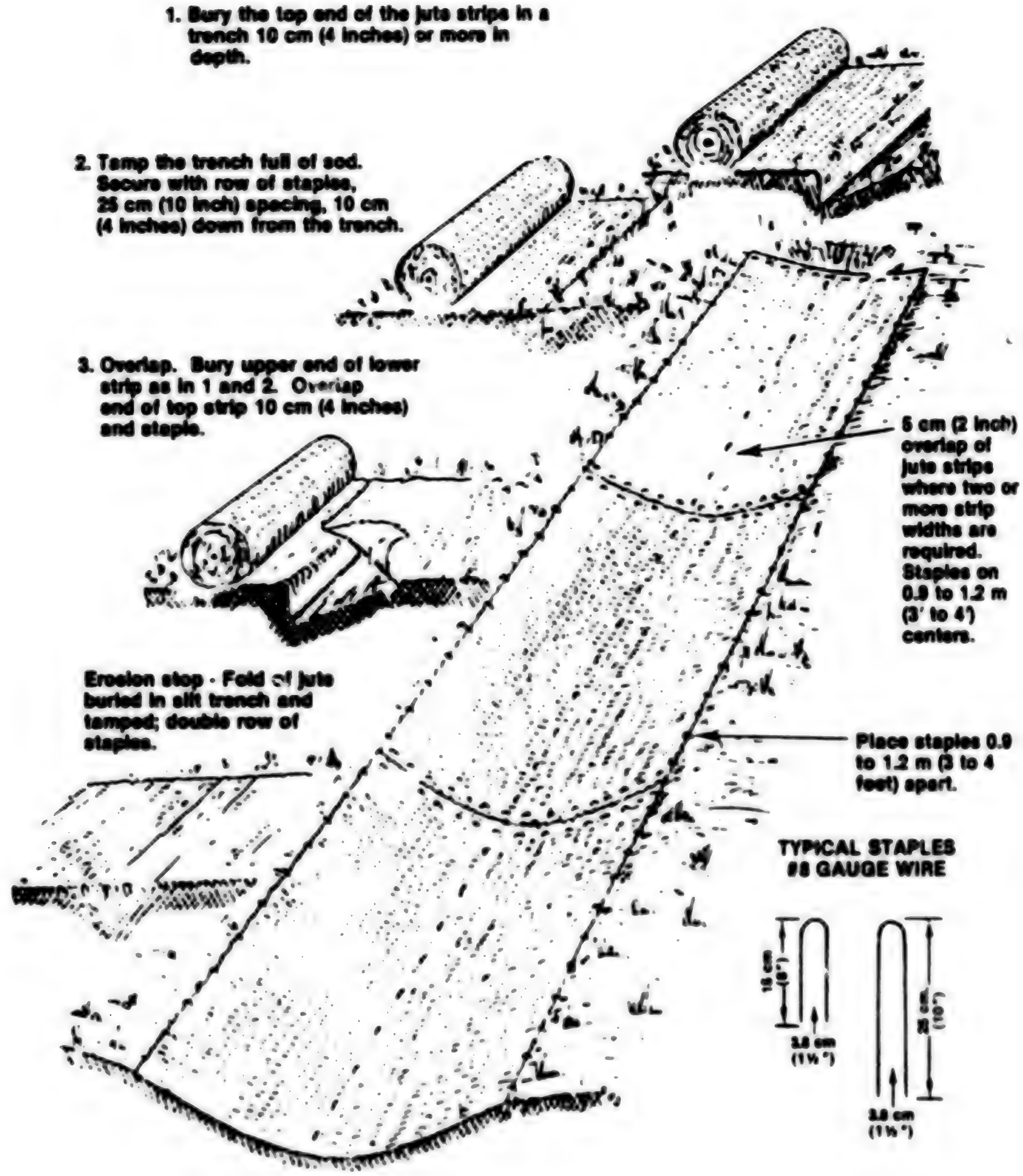

1. Bury the top end of the jute strips in a trench 10 cm (4 inches) or more in depth.
2. Tamp the trench full of sod. Secure with row of staples, 25 cm (10 inch) spacing, 10 cm (4 inches) down from the trench.
3. Overlap. Bury upper end of lower strip as in 1 and 2. Overlap end of top strip 10 cm (4 inches) and staple.
Erosion stop - Fold of jute buried in slit trench and tamped; double row of staples.
5 cm (2 inch) overlap of jute strips where two or more strip widths are required. Staples on 0.9 to 1.2 m (3' to 4') centers.
Place staples 0.9 to 1.2 m (3 to 4 feet) apart.
TYPICAL STAPLES #8 GAUGE WIRE
15 cm (6")
3.8 cm (1½")
25 cm (10")
3.8 cm (1½")

Figure 3.3-1. Installation of fabric netting for stabilization of critical areas (after Virginia State Water Control Board 1978).

## MAINTENANCE AND MANAGEMENT

Properly installed fabric netting will not require any maintenance. Runoff flows over well-secured netting with full soil surface contact prevent erosion of the soil underneath the netting.

## LABOR/MATERIALS

Netting and wire staples are available commercially. Netting made of natural fibers, such as jute and cellulose, are not as readily available as in the past. Synthetic fiber netting, such as fiberglass and plastic, are available from a number of manufacturers. When choosing a material, special attention should be given to the fact that some of these nettings will not deteriorate and will require removal by hand. Most synthetic nettings range in cost from $0.08 to $0.12 per 0.84 square meter (1 square yard). Staples can also be made from 8-gauge wire according to the dimensions in Figure 3.3-1. Proper installation of 93 square meters (1,000 square feet) of netting and two erosion stops takes about 3 to 4 man-hours.

## SOURCES OF INFORMATION

Additional information on the stabilization of critical areas can be obtained from:

- State Regulatory Authority
- Soil Conservation Service
- State Highway Department

References cited:

Virginia State Water Control Board. Best management practices handbook--agriculture. Richmond, VA; 1978.

### h. Food patches.

PURPOSE

A food patch is, by definition, any plot of domestic food plants (usually small grains) reserved for use by wild animals. If leguminous or woody plants are also included in the planting, the patches can be a source of wildlife cover. Food plots can easily be incorporated into almost any postmining land use objective because the size of the plots are relatively small and plots can be placed in areas where they will not interfere with other land use activities.

Food patches can either be planted for a specific species, or they can be general-purpose plantings, providing food for a variety of animals. The literature on plantings for specific species is well-documented and readily available and, for this reason, will not be repeated here. (See Rafaill and Vogel 1978; Hinkle et al. 1981a, b; and several excellent state publications listed in the references following Section 3.3.1.1, Planting Patterns.) General-purpose food patches, on the other hand, are less well-documented, but are very important because of the number and variety of wildlife served by them.

The success of food patches and the volume of food materials produced is sometimes dramatic. In a study in New Hampshire, where nine food patches were planted for pheasants, 339 kg of seed were produced per 0.4 hectare (746 pounds of seed per acre) (Gould no date). Costs averaged $3.38 per 45.4 kg (100 pounds) of seed produced and $25.24 per 0.4 hectare (1 acre). The most productive plot yielded 634 kg per 0.4 hectare (1,396 pounds per acre) at a cost of $1.86 per 45.4 kg (100 pounds); corresponding values for the least productive plant were 107 kg (235 pounds) and $10.70. Results of the study indicated that the pheasant population where the food patches were planted increased from 19 in September to 50 in November.

DEVELOPMENT

Most general-purpose food patches should be no smaller than 0.05 hectare (0.1 acre) in size and not larger than 0.4 hectare (1 acre). Several scattered plots are also better than grouped plots; long narrow patches are the best shape. Plots will be more readily used if they are located close to protective cover, such as a wood's edge or a rock or brushpile. The attractiveness of the patch will be further enhanced if strip plantings connect the food patches and cover. These strip plantings need be nothing more than a few rows of tall-growing legumes or a double row of woody shrubs or trees.

Several general-purpose food patch mixtures have been developed for various areas of the country and for locations where the seeds are available. Table 3.3-3 lists three mixtures suitable for the eastern U.S. (Shomon et al. 1966). Each should be planted in the spring in patches that are 0.2 to 0.4 hectare (0.5 to 1 acre) in size. Liming may be necessary to bring the pH of the soil to the preferred 6-6.5 range, and fertilizer is recommended at an application rate of 136-182 kg per 0.4 hectare (300-400 pounds per acre) of 5-10-10. Each of the mixtures was developed to group certain types of plants that grow well together and provide wildlife benefits over an extended period of time.

Table 3.3-3. Food patch mixtures for planting in spring for the eastern United States

| Species | Kilograms | (Pounds) |
|---|---|---|
| **Mixture #1 for 2.02 hectares (5 acres)** | | |
| Buckwheat | 4.5 | (10.0) |
| Grain sorghum | 4.1 | (9.0) |
| Foxtail millet | 6.8 | (15.0) |
| Proso millet | 6.8 | (15.0) |
| Kaffir | 4.1 | (9.0) |
| Sudangrass | 2.3 | (5.0) |
| Soybeans | 6.8 | (15.0) |
| Cowpeas | 5.9 | (13.0) |
| Vetch | 4.1 | (9.0) |
| Total kilograms (total pounds) | 45.4 | (100.0) |
| **Mixture #2 for 2.02 hectares (5 acres)** | | |
| Buckwheat | 6.8 | (15.0) |
| Foxtail millet | 6.8 | (15.0) |
| Sudangrass | 6.8 | (15.0) |
| Soybeans | 11.4 | (25.0) |
| Cowpeas | 13.6 | (30.0) |
| Total kilograms (total pounds) | 45.4 | (100.0) |
| **Mixture #3 for 2.02 hectares (5 acres)** | | |
| Proso millet | 8.0 | (17.5) |
| Grain sorghum | 11.4 | (25.0) |
| Sunflower | 3.4 | (7.5) |
| Total kilograms (total pounds) | 22.8 | (50.0) |

Source: From Shomon et al. 1966.

In choosing a seed mixture to plant, the greater the variety of seeds in the mix, the greater the potential number of species that will use the planting. However, the availability of certain seeds from suppliers may limit the use of certain mixtures.

## MAINTENANCE AND MANAGEMENT

Most of the plants listed in Table 3.3-3 are annuals, which means that they rapidly establish vegetative growth, flower, and die within one growing season. They reproduce only from the seed they produce during their life cycle and will rarely produce successful food patches during the second season without assistance.

Plots will essentially have to be retilled and sown each spring to be effective. Bushes and herbaceous growth will quickly cover a plot during the second growing season unless they are removed manually by tilling and/or controlled burning.

## LABOR/MATERIALS

See Sections 3.3.1.c, 3.3.1.d, and 3.3.1.e for appropriate equipment and labor estimates for establishing vegetative plantings.

## SOURCES OF INFORMATION

Additional information on food patches for wildlife can be obtained from:

- State Fish and Game Agency
- Soil Conservation Service
- U.S. Fish and Wildlife Service
- State Forestry Agency
- U.S. Forest Service

References cited:

Gould, E. W. Progress report of the southern New Hampshire pheasant demonstration and research project. New Hampshire Fish and Game Dept. Tech. Cir. 5; no date.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region I. U.S. Fish and Wildlife Service FWS/OBS-79/48.3.1; 1981a.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region II. U.S. Fish and Wildlife Service, FWS/OBS-79/48.3.2; 1981b.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service, FWS/OBS-78/84; 1978.

Shomon, J. J.; Ashbaugh, B. L.; Toman, C. C. Wildlife habitat improvement. New York: Nat. Audubon Society; 1966.

### 1. Planting patterns.

PURPOSE

The distribution of habitat types in a community can be a key determinant of the area's value to wildlife. Since use of an area is largely determined by the mobility of a species and the relative availability of food, water, cover, and other habitat requirements, the greater the interspersion of these habitat components (the more patchiness or diversity that exists in the community), the more valuable the area is to wildlife. Reclamation of surface-mined coal lands incorporating the interspersion of different vegetation types invariably increases the diversity and overall abundance of wildlife.

After determining what to plant, the next most important questions are "how" and "where" to plant. The planting pattern in many cases can be as important, if not more so, than what is planted. A food plot located in the middle of an open field will not receive nearly as much use as a similar plot located near a wood's edge. The placement of food plots near cover will further increase the attractiveness of the planting to wildlife.

With careful placement of wildlife plantings, food and shelter plots can easily be incorporated into almost any postmining land use scheme. Suggestions offered later in this section indicate planting schemes which would be compatible with several of the more common land use objectives and special areas in Appalachia.

DEVELOPMENT

Different types of vegetation have different values for wildlife. Trees and shrubs typically provide nesting habitat, cover, fawning areas, escape terrain, and foraging areas. Grasses and forbs generally provide food, but may also provide cover, nesting habitat, and escape terrain for smaller wildlife species. A wildlife biologist can determine those habitat requirements most needed by single target species or groups of target species. Those requirements can be provided through the spatial arrangement of selected vegetation types. Several excellent State and Federal publications which discuss regional planting patterns for wildlife are given at the end of this section.

Once the desired life forms (trees, shrubs, grasses, or forbs) are determined, native or introduced species which are adapted to the area can be planted in a spatial arrangement best suited to the site. Local Soil Conservation Service offices are sources of information for plants adapted to a particular area.

In most cases, when trying to maximize diversity, strip plantings are highly successful. Variety results from having bands of different types of vegetation (e.g., different growth forms, foliage retention periods, fruit retaining dates) planted in alternate rows. Some of the strips will be used by wildlife as travel lanes and runways. A random planting pattern may be more pleasing to the eye, but it creates gaps in the cover that some ground-dwelling birds and mammals are unwilling to cross. Appalachian game species, such as cottontail rabbit, bobwhite quail, and ruffed grouse should benefit significantly from such planting patterns. Travel lanes of bristly locust, alternating with two rows of shrubs, such as autumn olive, bicolor lespedeza, or tatarian honeysuckle, are recommended as general-purpose strip plantings (Rafaill and Vogel 1978). In areas where acid mine spoils are known or suspected to be a problem, sawtooth oak or toringo crabapple may be substituted for tatarian honeysuckle.

The "edge effect" of planting different species and different vegetation types next to each other is very important to wildlife to provide diversity of cover and food sources. The best designed edge effects include a gradual blending of vegetation, rather than an abrupt change. This may include using shrubs in transition from grassed to forested areas.

Specific guidelines for wildlife planting patterns, to promote diversity on special sites, can be summarized as follows (Hinkle et al. 1981):

### In Areas with Steep Slopes

- Plant two or three rows of trees above the top of the original highwall.
- Plant benches to alternating strips or blocks of herbaceous species and shrubs.
- Plant the edge of the bench near the outslope to a few rows of conifers.
- Plant the outslope to strips of herbs and woody plants that will also ensure quick erosion control.

### In Flat Areas

- Plant strips of grasses and legumes, that are 30 to 46 meters (100 to 150 feet) wide, with alternating strips of shrubs and/or trees that are 9 to 15 meters (30 to 50 feet) wide.
- In land reclaimed for forest, provide open areas that are at least 0.2 hectare (0.5 acre) in size, with a minimum of one patch per 16 hectares (40 acres). Seed to grass and/or legume species.

### In Pasture or Hay Fields

- Plant a strip of shrubs, not over 6 meters (20 feet) in width, around the field.

- Plant a clump of trees and shrubs at random locations on every 2 hectares (5 acres) of field.

- Fence special-use wildlife food plots.

In Forest Plantations

- In forest plantations, leave open areas (e.g., fire breaks) to provide more food and cover.

- Plant a single or double row of shrubs at the forest edge.

- Plant a double or single row of shrubs, spaced 2 meters (6 feet) apart, between rows of trees on Christmas tree plantations.

In Industrial Areas

- Plant shrubbery around office buildings. Emphasize those species with high wildlife food value.

In Unplanted Areas

- Locate escape cover of boulders, logs, slash, and brush.

In Streams

- Establish grasses or sedges on the bank as a food source.

- Establish trees and/or shrubs at intervals along the streambank as cover for wildlife and for shade for fish.

- Establish clump plantings of shrubs on moist, low-lying areas paralleling the stream to protect these areas from overuse by large animals. Management (i.e. fencing) to provide protection may also be necessary.

In and Around Impoundments

- Establish shoreline grasses, shrubs, and/or trees to provide food and cover.

- In shallow areas, establish aquatic plants for waterfowl cover and food. (Aquatic plantings may overprotect small fish, causing poor fish production.)

- Establish a mixture of grass and shrub patches on shorelines to encourage waterfowl breeding.

## MAINTENANCE AND MANAGEMENT

It should be remembered that vegetation changes with time; therefore, the quality and quantity of food and cover will, in time, be affected. If the landowner so desires, he can counteract this process of change to a great degree by initiating some maintenance practices. For example, open areas will become overgrown, thus requiring cutting, disking, or controlled burning to preserve the cover type. Practices such as these for maintaining open areas should be undertaken only after the broods of ground-nesting birds, such as bobwhite quail, have left the nest, generally in late summer. Recommendations for the best maintenance procedures can be obtained from professional wildlife biologists, conservationists, and foresters.

In Alabama, it is recommended that cutting, disking, or burning be done in late winter-early spring (February-March) while the ground cover is still brown and dormant and is more easily burned. This is also the best time to work last year's seed crop into the soil. This should be done before mating and nesting begins, so that new growth vegetation will be greening up when young ground nesting birds and other newborn wildlife begin to forage for food. This new growth quickly generates high quality forage following the peak stress (late winter) time for wildlife which rely heavily on browse and forage.

## LABOR/MATERIALS

Once the decision has been made to utilize a variety of wildlife plantings for reclamation, an appropriate planting pattern can be implemented at no substantial additional cost. Strip wildlife planting, as opposed to random planting, can even reduce costs by allowing personnel and machinery to concentrate their efforts in one area.

## SOURCES OF INFORMATION

Additional information on planting patterns for wildlife plants can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agencies
- Bureau of Land Management
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Soil Conservation Service

References cited:

Hinkle, C. R; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal-OSM Region II. U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.2; 1981.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; 1978.

Additional references:

Note: References relating to planting patterns around impoundments for fish or waterfowl have been deleted from the list below and placed in the reference lists for Sections 3.3.2.e (fish) and 3.3.2.g (waterfowl).

Allaire, P. N. Reclaimed surface mines: New potential for some North American birds. Am. Birds 32(1):3-5; 1978.

Allan, P. F.; Steiner, W. W, Autumn olive for wildlife and other conservation uses. USDA leaflet No. 458. U.S. Government Printing Office. Washington, DC; 1972.

Allen, R. H., Jr.; Waters, R. E. Bobwhite quail management: facts and fiction. Bulletin No. 5. Alabama Department of Conservation and Natural Resources. Division of Game and Fish; 1972.

Alverson, K. Cattle and fish on surface-mined land. Soil conservationist 34(4):4-6; 1973.

Anderson, W. L. Making land produce useful wildlife. USDA. Farmers' Bull. No. 2035. U.S. Govt. Printing Office, Washington DC; 1969.

Arner, D. H.; Davison, V. E. Wild turkeys on southeastern farms and woodlands. USDA Leaflet No. 526. U.S. Government Printing Office. Washington, DC; 1976.

Bailey, R. W. The wild turkey's management and future in North Carolina. North Carolina Wildlife Resources Commission. Raleigh, NC; 1976.

Bailey, R. W.; Rinell, K. T. History and management of the wild turkey in West Virginia. West Virginia Department of Natural Resources. Division of Fish and Game Bulletin 6; 1968.

Baxter, W. L.; Wolfe, C. W. The interspersion index as a technique for evaluation of bobwhite quail habitat. In: Morrison, J. A.; Lewis, J. C., eds. Proceedings first bobwhite quail symposium. Oklahoma St. University. Stillwater, OK; 1972:158-165.

Bevill, V.; Mahan, W.; Strange, T. Game on your land. Part 1 - small game and wood duck. South Carolina Wildlife and Marine Resources Department. Columbia, SC; 1978.

Brenner, F. J. Food and cover evaluation of strip mine plants as related to wildlife management. In: Surface mining and fish and wildlife needs in the Eastern U.S. U.S. Fish and Wildlife Service FWS/OBS-78/81; 1978.

Cottam, C.; Trefethen, J. B., eds. Whitewings: the life history, status, and management of the whitewinged dove. D. Van Nostrand Co., Inc. Princeton, NJ; 1968.

Davis, J. R. Management of Alabama wild turkeys. Alabama Department of Conservation and Natural Resources. Game and Fish Division Spec. Rep. 5. Montgomery, AL; 1976.

Davis, J. R. Management for mourning doves in Alabama. Special Report No. 6. Alabama Department of Conservation and Natural Resources. Game and Fish Division. Montgomery, AL; 1977.

Davis, J. R. Gray squirrel management in Alabama. Special Report No. 7. Alabama Department of Conservation and Natural Resources. Game and Fish Division. Montgomery, AL; 1978.

Davis, J. R. The whitetailed deer in Alabama. Special Report No. 8. Alabama Department of Conservation and Natural Resources. Game and Fish Division. Montgomery, AL; 1979.

Durell, J. Wildlife management practices. Kentucky Department of Fish and Wildlife Resources. Frankfort, KY; 1978.

Evans, K. E. Oak-pine and oak-hickory forest bird communities and management options. In: Proceedings of the Workshop: Management of Southern Forests for Nongame Birds, Atlanta, GA. January 24-26. USDA Forest Service General Technical Report SE-14. U.S. Forest Service. Southeastern Forest Experiment Station; 1978:76-89.

Evans, K. E. Forest management opportunities for songbirds. In: Proceedings of Forty-Third North American Wildlife Conference.; no date:69-77.

Evans, K. E.; Conner, R. N. Snag management. In: Proceedings of the Workshop: Management of North Central and Northeastern Forests for Nongame Birds, Minneapolis, MN. January 23-25. U.S. Forest Service General Technical Report NC-51. U.S. Forest Service. North Central Forest Experiment Station; 1979:214-225.

Georgia Department of Natural Resources. Wildlife on your land: practical management for the landowner. Georgia Department of Natural Resources. Atlanta, GA; no date.

Halls, L. K.; Ripley, T. H., eds. Deer browse plants of southern forests. U.S. Forest Service. Southern and Southeastern For. Exp. Stns.; 1961.

Hewitt, O. H. The wild turkey and its management. The Wildlife Society. Washington, DC; 1967.

Hill, C. E. Management of the white-tailed deer in North Carolina. N.C. Wildlife Resources Commission. Division of Game. Raleigh, NC; 1976.

Hill, E. P. The cottontail rabbit in Alabama. Ala. Agric. Exp. Stn. Bull. 440. Montgomery, AL; 1972.

Hosley, N. W. Selected references on management of white-tailed deer 1910 to 1966. U.S. Fish Wildl. Serv. Bureau Sport Fish. Wildl. Spec. Sci. Rep. 112; 1968.

Kight, J. How to have small game on your land: small game management in Georgia. Georgia Game and Fish Commission. Atlanta, GA; 1971.

Korschgen, L. J. Feeding habits and food. In: Hewitt, O. W., ed., The wild turkey and its management. The Wildl. Soc., Washington, DC; 1967:137-199.

Lay, D. W. Brief summary of turkey range management. In: Proc. First Natl. Wild Turkey Mgmt. Symp.; 1959:79-100.

Lay, D. W. The importance of variety to southern deer. Presented to Southeastern Association, Game and Fish Commissioners Meeting. Clearwater, FL. October 19-21; 1964.

Lewis, J. C. The world of the wild turkey, J. B. Lippincott Co. Philadelphia and New York; 1973.

Lindzey, J. S. Highlights of management. In: Hewitt, O. W., ed. The wild turkey and its management. The Wildl. Soc., Washington, DC; 1967:245-260.

Markley, M. H. Limiting factors. In: Hewitt, O. W., ed. The wild turkey and its management. The Wildl. Soc., Washington, D.C.; 1967:199-244.

May, J. R. Cottontail rabbits. Kentucky Department of Fish and Wildlife Resources. Frankfort, KY; no date.

Moore, G.; Bevill, V. Game on your land. Part 2 - turkey and deer. South Carolina Wildlife and Marine Resources Department. Columbia, SC; 1978.

North Carolina Wildlife Resources Commission. Management of the bobwhite quail. North Carolina Wildlife Resources Commission. Division of Game. Raleigh, NC; 1972.

North Carolina Wildlife Resources Commission. The eastern cottontail rabbit. North Carolina Wildlife Resources Commission. Division of Game. Raleigh, NC; 1973.

North Carolina Wildlife Resources Commission. Guide for the establishment of deer restoration areas. North Carolina Wildlife Resources Commission, Raleigh, NC; 1974.

North Carolina Wildlife Resources Commission. More wildlife through forestry. North Carolina Wildlife Resources Commission, Division of Game. Raleigh, NC; 1977.

Patton, D. R. A diversity index for quantifying habitat "edge." Wildl. Soc. Bull. 3:171-173; 1975.

Riley, C. V. Reclamation of coal strip-mine lands with reference to wildlife plantings. J. Wildl. Manage. 21:402-413; 1957.

Riley, C. V. Revegetation and management of critical sites for wildlife. In: J. B. Treethen, ed. Transactions of the 28th North American Wildlife and Natural Resources Conference. Wildl. Manage. Inst. Washington, DC. Also in Wildl. Rev. 112:17 (Abstr.); 1963:269-283.

Rosene, W., Jr. The bobwhite quail: its life and management. Rutgers University Press. New Brunswick, NJ; 1969.

Samuel, D. E.; Stauffer, J. R.; Hocutt, C. H.; Mason, W. T., eds. Surface mining and fish/wildlife needs in the eastern United States. Proceedings of a Symposium, FWS/OBS-78/81. West Virginia University. U.S. Fish and Wildlife Service; 1978.

Scott, V. E. Cavity-nesting birds of North American forests. U.S. Forest Service Handbook 511. U.S. Government Printing Office; 1977.

Stoddard, H. L. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons. New York, NY; 1931.

Tennessee Wildlife Resources Agency. Bobwhite quail: facts and management. Tennessee Wildlife Resources Agency. Wildlife Management Division. Nashville, TN; no date.

Trippensee, R. E. Wildlife mangagement: upland game and general principles. Volume I. McGraw-Hill. New York, NY; 1948.

Uhlig, H. G. The gray squirrel in West Virginia. W. Va. Cons. Comm. Div. Game Mgmt. Bull. 3. Charleston, WV; 1956.

U.S. Forest Service. How to manage woodlands for birds. NE-INF-31-76; no date.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

U.S Soil Conservation Service. Plants for a purpose. U.S. Department of Agriculture. Coffeeville, MS; 1978.

Van Hoey, A. F. Wildlife management with herbaceous cover. Management Series No. 4. Indiana Department of Natural Resources. Division of Fish and Wildlife. Indianapolis; IN; no date.

Yoakum, J.; Dasmann, W. P; Sanderson, H. R.; Mixon, C. M.; Crawford, H. S. Habitat improvement techniques. In: Schemnitz, S. D., ed. Wildlife management techniques manual. Washington, DC: The Wildlife Society; 1980:329-403.

### j. Use of native species and species suitable to wildlife.

### PURPOSE

Surface-mined areas can be reclaimed with species that not only stabilize the site, but also are of proven value to fish and wildlife. Some species provide both food and cover, while others are of special value only to select groups of wildlife. The decision about which plants to use depends on the management objective and wildlife needs in the mine plan area. In any case, the species chosen must be adapted to local site conditions (e.g., soil, climate, weather). Native species are well adapted to local conditions, but exotic species may also provide suitable food and cover. Many States encourage the use of native species, but their use is often limited by lack of availability.

Careful planning of the reclamation program to incorporate wildlife-enhancing plants can be rewarding to the landowner and society in general. The following pages highlight some of the major considerations in choosing the proper species.

### ILLUSTRATION

The special environmental characteristics of the permit area, as well as certain legal factors, will greatly influence the selection of materials to be planted. Some of the major considerations are (Hinkle et al. 1981a,b):

- Seed laws may affect the importation of seeds across State boundaries. A perfectly acceptable plant species in some States may be classified as a "noxious weed" in others. For example, West Virginia classifies multiflora rose as a noxious weed and will not allow its use as a reclamation plant, while the States of Georgia and Kentucky will tentatively accept it.

- Species chosen must be adaptable to specific site situations and intended uses. Considerations regarding these factors should include the following:

    - Special ecotypes or varieties adapted to the region should be used where possible.

    - Soil characteristics, such as pH, fertility, texture, depth, permeability, presence of toxic materials, and water-holding capacity influence the success of establishment. In most cases, topsoil is suitable for native species. The soil acidity (pH) should be considered when choosing species so that those tolerant to the pH can be used. Soil nutrition deficiencies may have to be overcome with fertilizer.

  - Local amount and seasonal distribution of precipitation and temperature regime affect success of establishment.

  - Elevation affects the length of the growing season.

  - The amount of solar radiation varies with the angle of the slope. Also, steep slopes are unsuitable for shallow-rooted plants.

  - The direction the slope faces (aspect) affects moisture, sunlight, soil temperature, and other factors related to successful establishment of plants.

  - Continuous exposure to wind causes water stress.

- When planting several species together, shade tolerance should be considered since overtopping of a species may reduce its ability to survive. Mixes of compatible species are important (i.e., compatible to the success for each of the other species, as well as for the intended use). Grasses and forbs provide runoff and erosion protection better than shrubs and trees, which provide cover and food for wildlife. Mixes may include warm-season and cool-season grasses, fast- and slow-growing grasses, or forbs and grasses. Legumes mixed with grasses add the extra feature of improving soil nitrogen. Mixtures are especially important on sites with highly variable microtopography and soils.

- Planting and seeding time should coincide with the best time of year for establishing a species, but must also be timely with regard to the completion of grading and shaping (i.e., cover is needed quickly to reduce erosion).

- Long-term management is important. Perennial species may replace themselves, while biennuals and annuals may need reseeding.

- Increased benefit to wildlife is accomplished by mixing several species with different growth forms, foliage-retention, and fruit-retention characteristics.

Both introduced and native species can meet the adaptability requirement for use on reclaimed sites. Generally, native plants are well adapted to local soils, climate, and weather conditions. However, conditions of the soil may be drastically altered upon mining so that species native to the site may not fare as well due to soil color changes, nutrient changes, structural changes, etc. Planning for reclamation should take all of these factors into consideration.

A very important factor in choosing species, other than adaptability, is availability. Seeds are generally less expensive than planting stock and provide a good means of revegetation where moisture is not limiting to germination. However, the higher cost of container-grown stock over seeds may be offset since they can be used on sites that are rocky, contain toxic soils, and where precipitation is limiting and quick establishment is necessary. Bare root stock are cheaper than containerized seedlings, but their use is limited to their dormant season and to sites with adequate moisture. Cuttings, rhizomes, and sprigs may be advantageous on harsh sites. Wildings and plugs transplanted by a clump vegetation transporter system (see Section 3.3.1.c) are also a good way of getting native species started on a site.

Seeds may be purchased from a seed supplier or collected from native plants. At the present time, new equipment is being developed and tested which will aid in the collection of seeds from native plants (U.S. Forest Service 1980). Since the use of native plants is a relatively new science, professionals should be consulted on their collection, cleaning, storage, treatment and use early in the reclamation planning process.

## SOURCES OF INFORMATION

The Soil Conservation Service Plant Materials Centers can provide excellent information on suitable plants. Centers are located at the following places:

Americus Plant Materials Center
P.O. Box 688
Americus, GA 31709
(912) 924-2286

Quicksand Plant Materials Center
Quicksand, KY 41363
(606) 666-5069

Coffeeville Plant Materials Center
Coffeeville, MS 38922
(601) 675-2588

National Plant Materials Center
Building 509, ARC
Beltsville, MD 20705

Personnel at these centers can provide information on tested species, and, in some cases, limited stock is available for experimental purposes.

Information on equipment development and testing for collecting, transplanting, and handling plant seeds and stock can be obtained from the U.S. Forest Service (U.S. Forest Service 1980).

Information on plant species suitable for wildlife enhancement may be obtained from:

- SCS Plant Material Centers listed above
- State Fish and Game Agencies
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- U.S. Army Corps of Engineers

References cited:

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region I. U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.1; 1981a.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region II. U.S. Fish and Wildlife Service. FWS/OBS-79/48.3.2; 1981b.

U.S. Forest Service. Equipment development and test program - 1979-80 Progress and Plans; September 1980.

Additional references:

Barnhisel, R. I.; Powell, J. L.; Akin, G. W. Keys to sucessful reclamation in western Kentucky. *In*: Third Symposium on Surface Mining and Reclamation. Volume II, NCA/BCR Coal Conference and Expo II; October 21-23, 1975.

Chironis, N. P. Guide to plants for mine spoils. *In*: N. P. Chironis, ed. Coal age operating handbook of coal surface mining and reclamation. Vol. 2 - Coal Age Library of Operating Handbooks. New York: Coal Age Mining Informational Services, McGraw-Hill, Inc.; 1978.

Fowler, D. K.; Adkisson, L. F. Survival and growth of wildlife shrubs and trees on acid mine spoil. Norris, TN: Tennessee Valley Authority, Technical Note B37; January 1980.

MacLauchlan, R. S. The role of the Soil Conservation Service's Plant Materials Centers in reclaiming surface-mined lands. *In*: Third Symposium on Surface Mining and Reclamation. Volume II, NCA/BCR Coal Conference and Expo II; October 21-23, 1975.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; July 1978.

Samuel, D. E.; Stauffer, J. R.; Hocult, C. H., eds. Surface mining and fish/wildlife needs in the eastern United States - Proceedings of a Symposium. U.S. Fish and Wildlife Service. FWS/OBS-78/81; December 1978.

U.S. Fish and Wildlife Service. Mined land reclamation for fish and wildlife in the eastern United States. FWS/OBS-78/95; November 1978.

U.S. Forest Service. Wildlife habitat management handbook - Southern Region. Atlanta, GA: FSH 2609.23; February 1971.

U.S. Forest Service. User guide to Vegetation - Mining and reclamation in the West. Ogden, UT: Report INT-64, Intermtn. Forest and Range Expt. Station, General Technical Rpt. INT-64; November 1979.

### k. Grazing management.

#### PURPOSE

Livestock production is a viable and profitable option as a land use goal in central and southern Appalachia. Where mountaintop removal is practiced, large flat areas remain which are often transformed into grazing meadows. When new cattle range is created, the grazing management program which is instituted can have a significant effect on wildlife in the area. The most important concerns are how, when, and to what extent a pasture is grazed. Also, where fields adjoin wooded areas, the restriction of woodland grazing is important. Studies have shown that, where moderate grazing of pastures is practiced, certain habitats may be improved for wildlife (Weatherill and Keith 1969). On the other hand, overgrazing, which sometimes occurs in woodlands, can remove 50% or more of the bird species on an area (Dambach and Good 1940).

Grazing systems currently in practice include year-long, continuous, deferred rotation/rest rotation, common use, and alternate use by different kinds of livestock (Buttery and Shields 1975). The management system chosen can potentially result in many long-term benefits, not only in terms of increased productivity of the land to support grazing, but also by increasing wildlife populations which otherwise would be depressed.

#### DEVELOPMENT

##### Year-long Grazing

This is probably the most detrimental form of grazing management to wildlife. The pasture is often overgrazed to the point where range plants are never given the opportunity to develop adequate food and cover to support birds and small mammals. Stock may also denude certain areas of vegetation to the point where erosion can cause siltation of streams and degrade fish habitat.

##### Continuous Grazing

Although year-long grazing is continuous, not all continuous grazing is year-long. Continuous grazing may be for that part of a year that grazing is feasible (e.g., high mountain ranges grazed June-September). If the season of grazing of an area can be selected, spring and early summer would probably rank as the most important to wildlife, and therefore the most important time to not graze. It is during these times that birds and small mammals are raising young and have the greatest need for high-quality food. Heavy grazing during these times can trample nests and remove the most tender vegetation preferred by wildlife. The remaining seasons, in order of importance to wildlife, would be (from most important to least) late summer, fall, and winter.

## Deferred Rotation/Rest Rotation Grazing

Deferred grazing is the discontinuance of grazing on an area for a specified time. An area can be allowed to recover from intense grazing pressure by allowing cattle to graze elsewhere for a certain period of time, preferably during the growing season. However, as the deferred pasture is recovering, the grazed pasture is nearly always placed under heavy use. This can be offset by placing a limit on the number of cattle allowed to graze within a given area.

## Common Use Grazing

Common use grazing is the use of an area by more than one kind of animal, either at the same time or at different times. Since cattle and horses prefer grasses, sheep prefer forbs, and goats prefer shrubs, almost all of the vegetation on an area could potentially be cut back, depending on the variety and number of animals which use the area. Common use grazing, in this regard, can be very detrimental to wildlife habitat because of the variety of vegetation types which might be affected.

## Alternate Use Grazing

Alternating the kinds of grazing animals that utilize a pasture in different years can often be extremely beneficial to wildlife. It has been used to improve areas that have deteriorated to the point where the vegetative cover is largely forbs. In this management scheme, certain vegetation types on an area will be allowed to recover, while others will be alternately used. This will, in turn, allow wildlife groups which were depressed a chance to recover on an area. A commonly used alternate use grazing system allows cattle to graze a pasture for 2-3 years, and then be replaced for 1-2 years by sheep.

## Restriction of Grazing

One of the most detrimental grazing management practices to wildlife is allowing livestock to roam freely from pastureland into surrounding wooded areas. When livestock are not restricted by fencing, they wander into woods to seek shade and consume woodland ground cover. Plants are then trampled, as well as eaten. In a study in Ohio, it was found that protected woods supported more than twice the bird population--both in terms of individuals and species--than did grazed woods (Dambach and Good 1940). Furthermore, none of the species which nested on the ground in the protected woods was found in the grazed woods.

## SOURCES OF INFORMATION

References cited:

Buttery, R. F.; Shields, P. W. Range management practices and bird habitat values. In: Proceedings of the symposium on management of forest and range habitats for nongame birds. Tucson, AR: U.S. Forest Service General Tech. Rpt. WO-1; 1975.

Dambach, C. A.; Good, E. E. The effect of certain land use practices on populations of breeding birds in southwestern Ohio. J. Wildl. Manage. 4(1):63-76; 1940.

Weatherill, R. G.; Keith, L. B. The effects of livestock grazing on an aspen forest community. Alberta Dept. Lands and Forests. Fish and Wildlife Division. Tech. Bull. 1; 1969.

## 3.3.2 Water Resources Improvement and Development

### a. Stream improvements: mitigation and restoration techniques.

### PURPOSE

Stream improvements can be required by the regulatory authority on sites where aquatic habitats are disturbed by mining activities. Mitigation of unavoidable damage to an aquatic habitat often takes the form of improving remaining aquatic resources. Restoration, on the other hand, is necessary when a stream is directly affected by being mined through or diverted. Restoration and mitigation techniques which should prove most useful in central and southern Appalachia are the construction of artificial channels and meanders, the development of pools and riffles, and the creation of fish shelters. Artificial channels and meanders create new aquatic habitat, while the development of pools, riffles, and other shelters enhances or restores existing aquatic resources.

### DEVELOPMENT

#### Fish Shelters

Simple techniques can provide useful fish shelters in wide, shallow streams with fast currents and limited natural shelter. Anchored logs provide excellent cover (Section 3.3.2.f, Fish Shelters in Ponds and Lakes), but should be placed where they will not catch trash and create an unwanted dam. Large boulders, 0.5 cubic meters (two-thirds of a cubic yard) or larger, also make effective fish shelters. They should be placed with a front-end loader or other suitable machinery in areas with gravel bottoms to prevent the boulders from becoming buried in finer materials. One boulder for every 38 square meters (300 square feet) of channel surface can be considered a maximum (U.S. Forest Service 1969). In all cases, soft erodible banks should be protected by careful choice of equipment access and proper placement of in-stream structures to avoid excessive current deflection.

#### Dams

Pools provide deepwater cover, feeding, resting, and spawning habitat, while riffles are used for spawning by many fish species. In most cases, they are created by placing a low check dam across a mountain stream. Experience with most check dams shows that, after dam completion and upstream pool formation, a pool is formed below the dam by scouring during floods, while above the dam, the upstream pool fills with gravel and becomes a riffle area. Check dams, which need be no more than 0.3 meter (12 inches) above the stream bottom to be effective, can be constructed of logs, boards, rocks, posts and wire, and gabions (for details of gabion construction; see Section 3.3.2.b, Streambank Protection).

Dams should never be built so high that floodwaters will be forced over the bank at either end. This is extremely important to keep in mind because dams reduce the gradient of the stream channel, thus increasing the cross section of the flow.

The width of dams is also important. Restrict log-type dams to channel widths of 6.1 meters (20 feet) or less. Simple rock dams frequently fail when constructed wider than 3.1 or 3.7 meters (10 or 12 feet). Rock and wire dams may be used to span wider streams when maximum flood volumes are less than 2.8 cubic meters (100 cubic feet) per second.

Location of dams is important. Sites along straight sections of narrow channels reduce costs and possible damage.

Directing the flow through wide notches, greater than one-fourth the total width of the dam, may be desirable. This will help provide the scouring action needed during low-flow periods. Other structures, such as opposing deflectors, can be used where increased scouring is desired.

### Structures

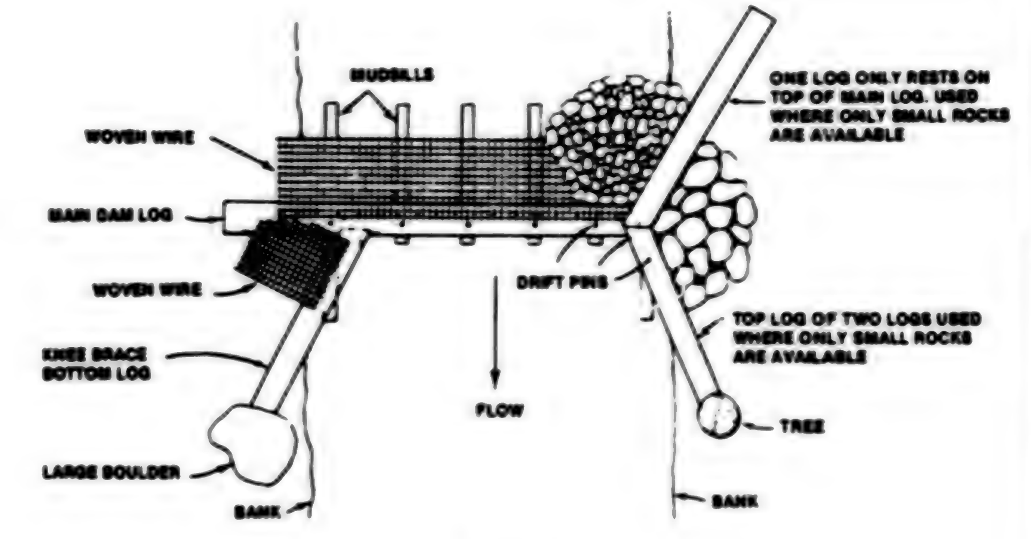
K-Dam. The K-dam (Figures 3.3-2 and 3.3-3) is highly reliable when properly installed. Installation costs are generally less than those for log and board dams. As with all log dams, streams with narrow channel widths, low gradients, and low-volume flows are most suitable for these structures.

The K-dam obtains its name from the knee braces used at each end of the dam which, when viewed from above, give the dam the shape of the letter K. Logs, called mudsills, are placed beneath the dam parallel to the streamflow and furnish the base on which the upstream face of the dam is constructed.

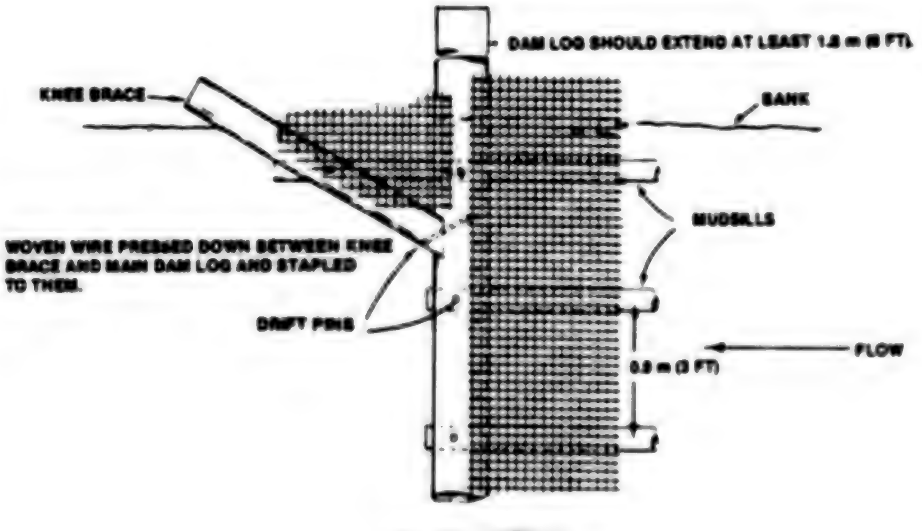
Construction should start with excavations for the ends of the dam and the mudsills. Place the ends of the dam 1.8 meters (6 feet) or more into the bank; the excavation for the mudsills should be at least one-half of their diameter. Mudsills should not be spaced farther than 0.9 meter (3 feet) from center to center.

In streams with low flow, it is possible to place the mudsills in position first and then lower the main dam on top of them. However, if there is a sizable volume of water to work in, it is easier to place the main dam log in position first and then slide the ends of the mudsills underneath the log. Drift pins, as shown in Figure 3.3-2, can hold the mudsills in place.

After the mudsills and dam log are in place, woven wire is stapled to the top of the log and pressed into place against the mudsills to which it is also stapled. The woven wire extends up the banks at least 0.9 to 1.2 meters (3 to 4 feet) and into the bank excavations at the ends of the dam. A layer of rocks of a larger diameter than the openings in the woven wire is carefully laid on the woven wire. This layer of rocks is covered with a thick seal of water-washed gravel, which is also carefully tamped in around the ends of the log extending into the bank excavation. The application of this gravel seal


MUDSILLS
WOVEN WIRE
MAIN DAM LOG
WOVEN WIRE
KNEE BRACE BOTTOM LOG
LARGE BOULDER
BANK
DRIFT PINS
FLOW
ONE LOG ONLY RESTS ON TOP OF MAIN LOG. USED WHERE ONLY SMALL ROCKS ARE AVAILABLE
TOP LOG OF TWO LOGS USED WHERE ONLY SMALL ROCKS ARE AVAILABLE
TREE
BANK

K—DAM
PLAN VIEW
SHOWING ONE END AND SEAL PARTLY CONSTRUCTED


DAM LOG SHOULD EXTEND AT LEAST 1.8 m (6 FT)
KNEE BRACE
BANK
MUDSILLS
WOVEN WIRE PRESSED DOWN BETWEEN KNEE BRACE AND MAIN DAM LOG AND STAPLED TO THEM.
DRIFT PINS
FLOW
0.9 m (3 FT)

K—DAM DETAIL
PLAN VIEW
CLOSE UP OF ONE END WITH WIRE IN PLACE

Figure 3.3-2. K-dams (U.S. Forest Service 1969).

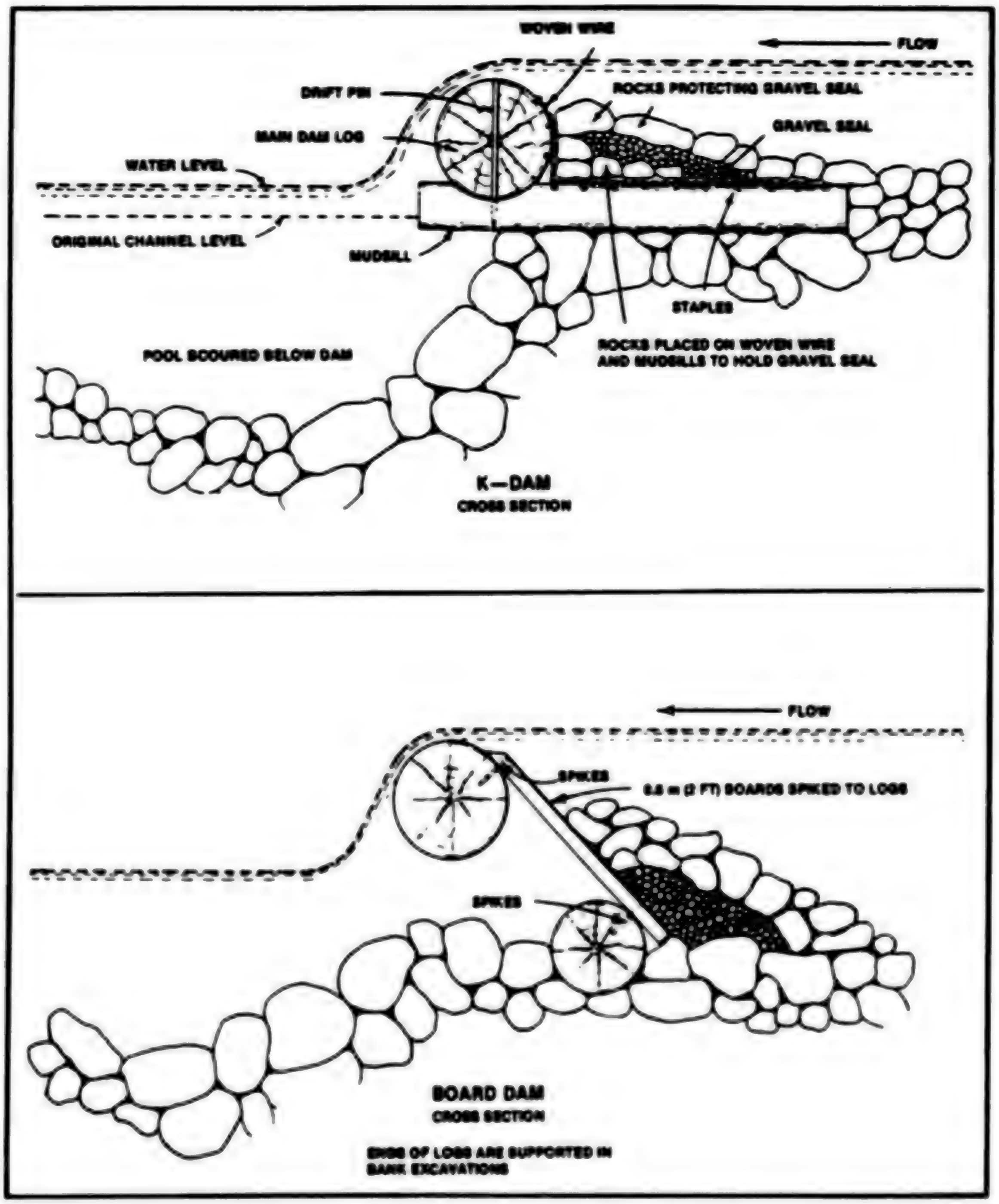


Figure 3.3-3. K-dams and board dams (from U.S. Forest Service 1969).

should start at the ends of the dam and work toward the center of the stream. The gravel seal is finally given a protective covering of large rocks to prevent its being swept away in high water. Figure 3.3-3 shows, in detail, how the dam is sealed.

Knee braces are installed as shown in Figure 3.3-2. These are unnecessary where the main log is braced behind trees or large boulders. The knee braces are securely drift-pinned to the main log and extend into the banks for good sound footing. Woven wire is next stapled to the knee brace and forced down into the opening between it and the streambank. One edge of the wire is stapled to the main dam log, and the pocket thus created is filled with carefully laid large rocks. The floor of this pocket may be given additional strength by extending the mudsill forward at the end of the dam. Rock work starts with the knee brace as a toe and extends up and over the end of the dam.

Where only small rocks are available, it is often desirable to build up the knee brace with another log and construct a cribbing by extending a log upstream as shown at the right end of the dam in Figure 3.3-2.

Rock work at the ends of the dam should extend up the banks above the high-water level.

When the dam fills, the water should pour over the full length of the log between the knee braces. This keeps the entire log wet and less subject to rotting.

Board Dam. Boards, in place of mudsills and woven wire, are sometimes used in the construction of log dams. This is a more expensive method of construction, but is very effective on streams where there is little flow. Construction costs may be reduced where heavy equipment, such as a backhoe, can be used to do the excavation work. Under these circumstances, it is much easier to make dams watertight by the use of boards. Board dams require special construction, as shown in Figure 3.3-3. The main dam log is held slightly above the channel level of the stream by keeping the bottom of the bank excavations higher than the channel level. Boards are nailed flush with the top of the main log and are supported on the lower end by a log placed on the stream bottom. This bottom log also extends into excavations in the banks similar to the main dam log, but dug to the same level as the channel. Boards also extend into the excavations in the banks for a short distance. The bottom end of the boards are cut to conform to the unevenness of the stream bottom. Construction at the ends of the dam is the same as for the K-dam.

Board dams are best suited to rocky streams, where the banks can be excavated to expose strata that are solid enough to support the weight of the dam. Very short spans are also recommended because there is no support to the main dam log except at the ends.

Green, rough lumber, at least 5 cm (2 inches) thick, is satisfactory for board dams. Soak dry lumber before use so that it will not expand and buckle after being nailed in place. Almost any species of wood is suitable as it will be continually immersed and thus subject to little rot. However, poplar, aspen, and related species should be avoided because they lack strength when wet.

Simple Log Dams. Where flooding is not severe and the bottom materials are not subject to excessive scouring, dams may be constructed by spanning the stream with two logs, as shown in Figure 3.3-4. The construction differs from the K-dam because the woven wire and mudsills in the seal are eliminated and replaced with a log placed upstream from the main dam log and flush with the streambed. Other features of the simple log dam are essentially the same as those for the K-dam, although the knee braces may also be eliminated if the banks are hard and large rocks are available for the construction at the ends of the dam.

Use simple log dams only where excessive undercutting will not result in loss of the seal. Where there is doubt, standard K-dam construction using mudsills and woven wire or boards is usually the best guarantee against undercutting.

Rock Dams. Rock dams are most useful on small streams 3.1 to 3.7 meters (10 to 12 feet) wide that are not subject to severe flooding. Large oblong rocks about 1.2 meters (4 feet) long are arranged in an upstream arch for strength and sealed with small rocks and gravel, as with other dams (Figure 3.3-5). Naturally occurring boulders in the streambed can often be used as keystones for additional strength. Rock construction should be extended onto the banks to prevent the dam from washing out. Smaller rocks can be used for this purpose.

## Current Deflectors

Current deflectors are used to maintain a deep channel with a swift current by redirecting existing currents. Built at an angle to the flow and only part of the way across the channel, deflectors can be of log, rock, or gabion construction almost identical to check dams. Placement of the deflector is very important because deflectors can cause severe bank erosion or pool siltation if improperly installed. In an ideal situation, a series of current deflectors would alternate from bank to bank, creating a natural, twisting stream pattern (Figure 3.3-6). This configuration has been shown to be effective in restoring habitat in channelized streams (Barton and Winger 1973). Deflectors can also be constructed in opposing pairs to form a 'V', but these tend to increase current velocities too much and easily catch debris, which blocks the channel. As with check dams, deflectors need not be high to be effective. Low deflectors are also less susceptible to flood damage.

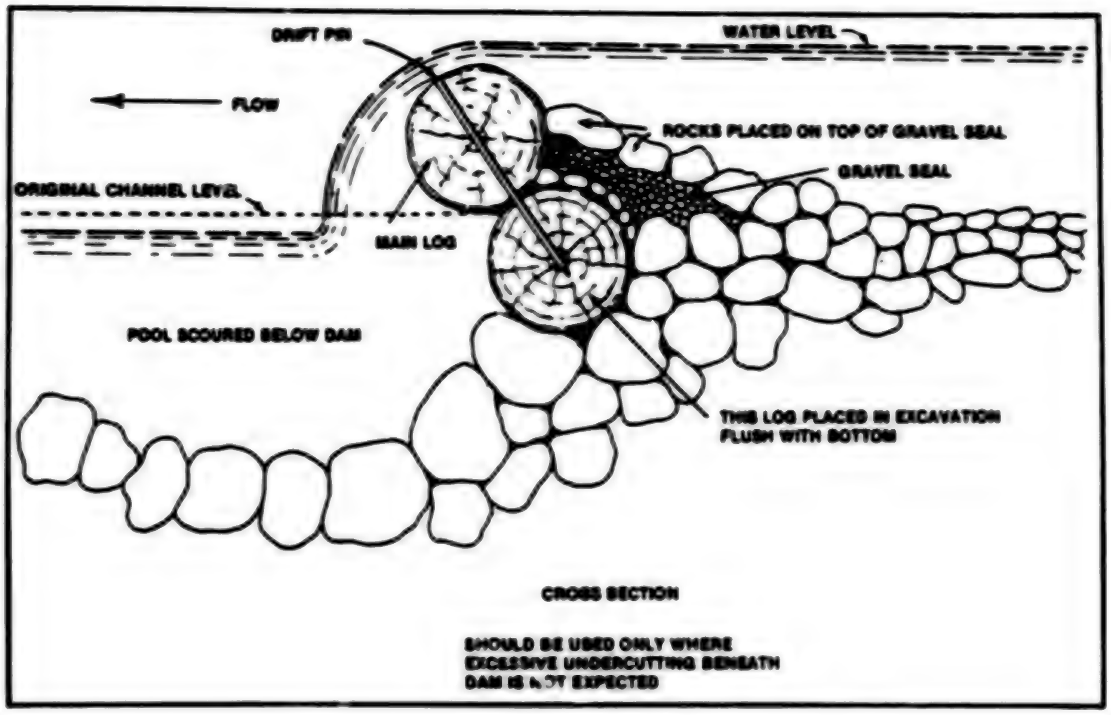

DRIFT PIN
WATER LEVEL
FLOW
ROCKS PLACED ON TOP OF GRAVEL SEAL
GRAVEL SEAL
ORIGINAL CHANNEL LEVEL
MAIN LOG
POOL SCOURED BELOW DAM
THIS LOG PLACED IN EXCAVATION FLUSH WITH BOTTOM
CROSS SECTION
SHOULD BE USED ONLY WHERE EXCESSIVE UNDERCUTTING BENEATH DAM IS NOT EXPECTED

Figure 3.3-4. Cross section of log dam (from U.S. Forest Service 1969).

### Artificial Channels and Meanders

Artificial channels and meanders are used to restore or replace aquatic habitat in severely disturbed or diverted streams. They are often used to reduce the stream gradient and increase the stream length. Artificial channels and meanders should be developed under the guidance of a fisheries biologist and a civil engineer in order to satisfy necessary biological and engineering requirements. Assistance should be enlisted when possible from the State fish and game and other agencies or from the Soil Conservation Service, which has considerable experience in stream channel development. Minimum flows, bottom materials, pool-riffle ratio, depth, width, gradient, and streambank vegetation must all be considered when planning an artificial channel or channel restoration (Hinkle et al. 1981). Design and construction of an artificial channel is very site-specific, depending on region, water quality, geology and soils, and existing aquatic communities.

## MAINTENANCE AND MANAGEMENT

Most in-stream improvement structures require no maintenance under normal conditions. Extreme floods, however, can damage any structure or bury it under sediment or debris. Repair or clearing of structures may not always be desirable or beneficial because the disturbance caused by maintenance activities may weaken the structure or cause extreme siltation downstream.

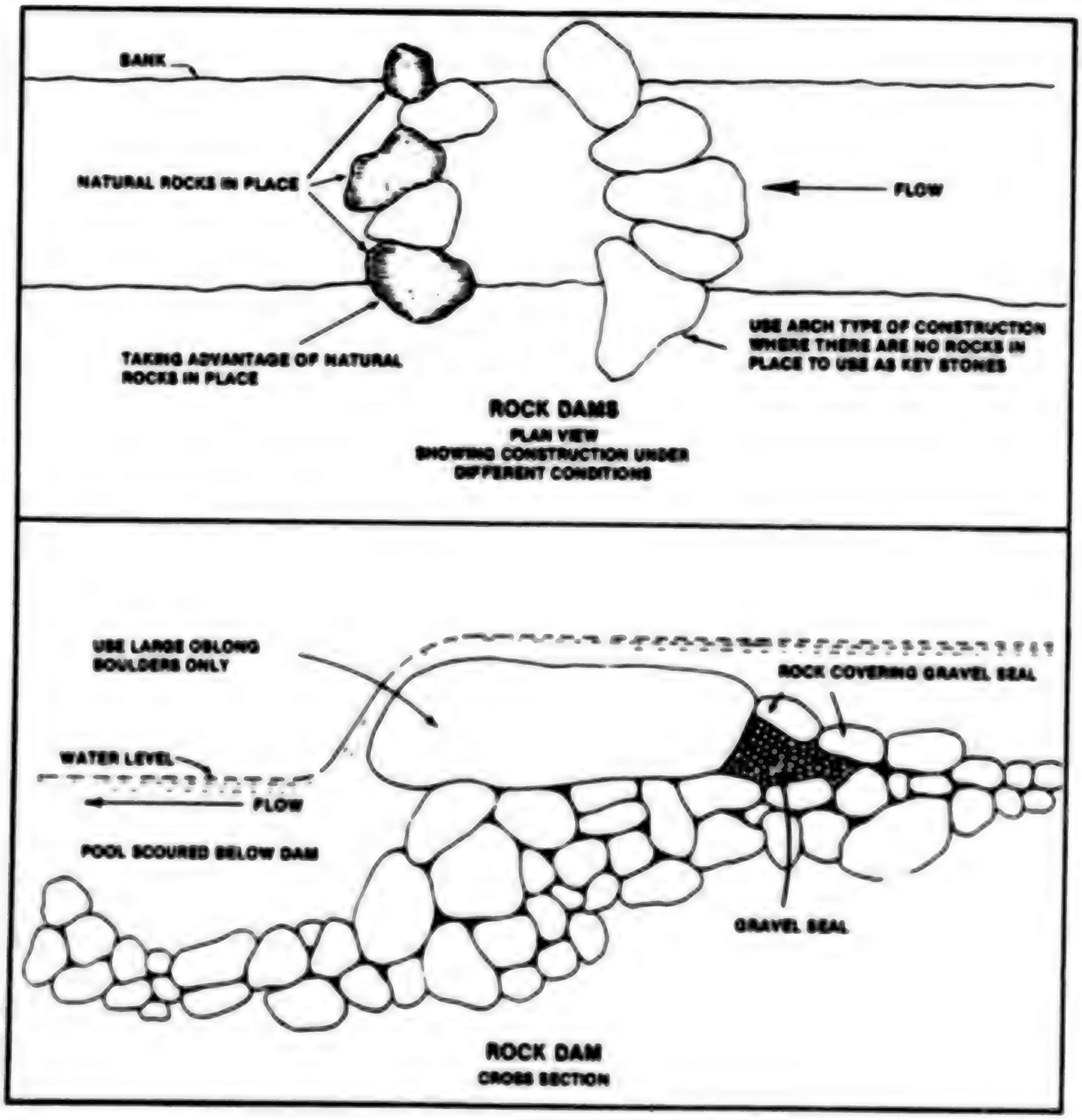

BANK
NATURAL ROCKS IN PLACE
FLOW
TAKING ADVANTAGE OF NATURAL ROCKS IN PLACE
USE ARCH TYPE OF CONSTRUCTION WHERE THERE ARE NO ROCKS IN PLACE TO USE AS KEY STONES
ROCK DAMS
PLAN VIEW
SHOWING CONSTRUCTION UNDER DIFFERENT CONDITIONS
USE LARGE OBLONG BOULDERS ONLY
ROCK COVERING GRAVEL SEAL
WATER LEVEL
FLOW
POOL SCOURED BELOW DAM
GRAVEL SEAL
ROCK DAM
CROSS SECTION

Figure 3.3-5. Rock dams (from U.S. Forest Service 1969).

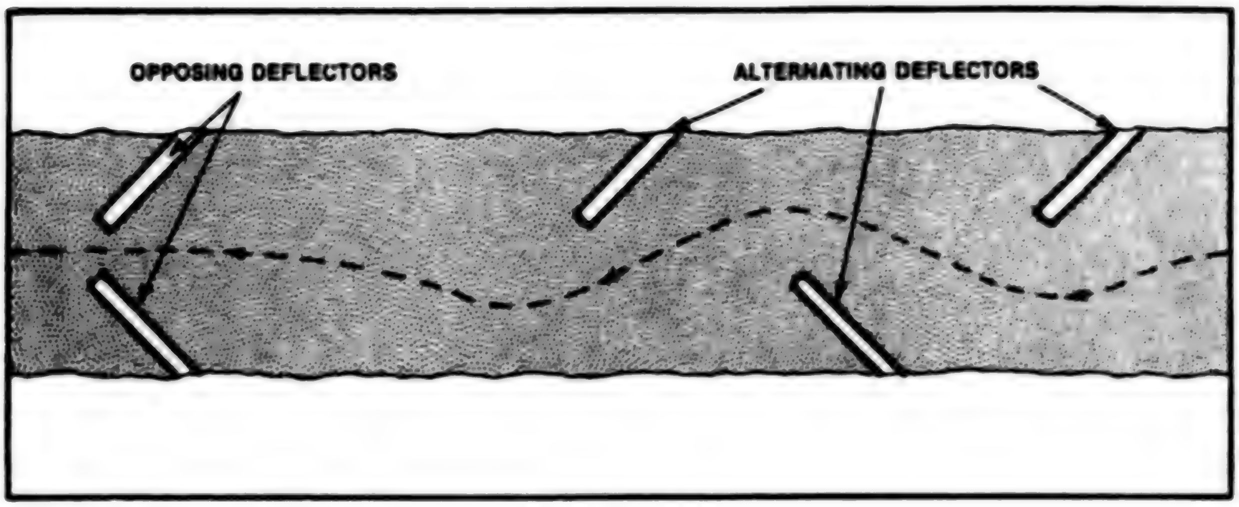


Figure 3.3-6. Current deflectors (after U.S. Fish and Wildlife Service 1978).

## LABOR/MATERIALS

Construction of log, board, and rock check dams requires 1 to 4 man-days to complete, depending upon channel width, soil conditions, and access to needed materials. Materials for these structures are generally available on most mine sites, although some hauling may be necessary. Heavy equipment is generally not needed for constructing these structures; however, boulder placement may require the use of machinery, depending on the size of the materials used.

## SOURCES OF INFORMATION

Additional information on stream improvement can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency
- Soil Conservation Service
- U.S. Fish and Wildlife Service

References cited:

Barton, J. R.; Winger, P. V. A study of the channelization of the Weber River, Summit County, Utah. Utah Division of Wildlife Resources and Utah State Department of Highways: Final report; 1973.

Hinkle, C. R.; Ambrose, R. E.; Wenzel, C. R. A handbook for meeting fish and wildlife information needs to surface mine coal - OSM Region IV. Washington, DC: U.S. Fish and Wildlife Service, FWS/OBS-79/48.3.2; February 1981.

U.S. Fish and Wildlife Service. Western reservoir and stream habitat improvement handbook. FWS/OBS-78/56; 1978.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

Additional references:

Bennett, A. C. Management of relocated streams and ditches in surface-mined areas. Paper presented at Texas A&M University, Surface Mine Reclamation Workshop, Oct. 24-25, 1979.

Corning, R. V., et al. (ed.). Symposium on stream channel modification, Proceedings of a symposium. Harrisonburg, VA: 1975.

Federal Highway Administration. Restoration of fish habitat in relocated streams. Implementation package FHWA-IP-79-3. Washington, DC: Supt. of Documents, GPO, Stock #050-001-00167-5; 1979.

McClellan, T. J. Ecological recovery of realigned stream channels. Federal Highway Administration, Rpt. No. FHWA-CR-74-1. NTIS No. PB 266-657; 1974.

Swales, S.; Ohara, K. Instream habitat improvement devices and their use in freshwater fisheries management. Jour. Env. Mgmt. 10(2); 1980.

Wildlife Management Institute. Stream renovation: A necessary management practice for "208" programs. Washington, DC: Wildl. Mgmt. Institute; 1980.

Wydoski, R. S.; Duff, D. A. Indexed bibliography on stream habitat improvement. Washington, DC: Bureau of Land Management, Technical Note No. 322; 1978.

b. Streambank protection.

PURPOSE

The purpose of streambank protection is to:

- prevent bank erosion and subsequent sedimentation
- prevent the destruction of riparian (streambank) habitat

Aquatic habitat can easily be destroyed as a result of streambank undercutting and sloughing off of bank material into the stream. When this occurs, riparian vegetation is often washed away, resulting in the loss of valuable wildlife cover for land animals and shading for aquatic animals. Three common structures used to stabilize streambanks are gabion mats, gabion deflectors, and riprap. They all have drawbacks because they provide poor hiding places for fish and tend to speed up the water velocity. However, bank erosion can be a very serious problem, and these structures should be used if revegetation or other methods to protect the bank do not work. The ultimate goal is to establish and/or maintain the streambank vegetation.

DEVELOPMENT

The basic elements of a gabion structure are rectangular wire-mesh cages and rock. Standard gabion mat sizes are given below:

| Dimensions (meters) | Approximate equivalents (U.S. units) | No. of diaphragms (partitions) | Capacity | |
|---|---|---|---|---|
| | | | Cubic meters | Cubic yards |
| 2 X 1 X 1 | 6'6" X 3'3" X 3'3" | 1 | 2 | 2.6 |
| 3 X 1 X 1 | 9'9" X 3'3" X 3'3" | 2 | 3 | 3.9 |
| 4 X 1 X 1 | 13'1" X 3'3" x 3'3" | 3 | 4 | 5.2 |
| 2 X 1 X 0.5 | 6'6" X 3'3" X 1'8" | 1 | 1 | 1.3 |
| 3 X 1 X 0.5 | 9'9" X 3'3" X 1'8" | 2 | 1.5 | 2.0 |
| 4 X 1 X 0.5 | 13'1" X 3'3" X 1'8" | 3 | 2 | 2.6 |
| 2 X 1 X 0.3 | 6'6" X 3'3" X 1' | 1 | 0.6 | 0.8 |
| 3 X 1 X 0.3 | 9'9" X 3'3" X 1' | 2 | 0.9 | 1.2 |
| 4 X 1 X 0.3 | 13'1" X 3'3" X 1' | 3 | 1.2 | 1.6 |

Fractional size mats may be placed along the slope of a streambank (Figure 3.3-7) to prevent erosion. It is recommended that the wire baskets used to build the mats be assembled in place, formed, and stretched out prior to filling them with rock. Where more than one mat needs tying together, it is easier to accomplish this prior to filling the mat with rock. Placing the rock in the basket by hand is preferable to machine filling because sagging is less likely to occur in hand-filled baskets. The top of the basket or lid should be closed and fastened on the downstream side to prevent debris from ripping it off. In addition to these gabion mats, tire mats made from discarded tires bound together with nylon or wire may be used (West Virginia Department of Natural Resources no date).

Stream deflectors may be constructed by using gabion baskets (Figure 3.3-8). These deflectors direct water flow toward the center of the stream, deepening and cleaning stream channels which have sand or gravel bottoms and protecting streambanks by directing the current away. Combinations of deflectors may be used (Figure 3.3-9) to form pools, build bars, or protect the banks of a stream. One problem with the double (V) deflector system is that trash often collects in the narrowed channel, creating an obstruction in the stream. This can be prevented, to some extent, by keeping the distance between opposing deflectors at least as far away as half the width of the stream.

Log cribbing may also be used as an effective means of protecting the streambank (Figure 3.3-10). Here, rock backfilling is used for added support. Water is prevented from getting behind the cribbing by securely anchoring and protecting the upstream end (West Virginia Department of Natural Resources no date).

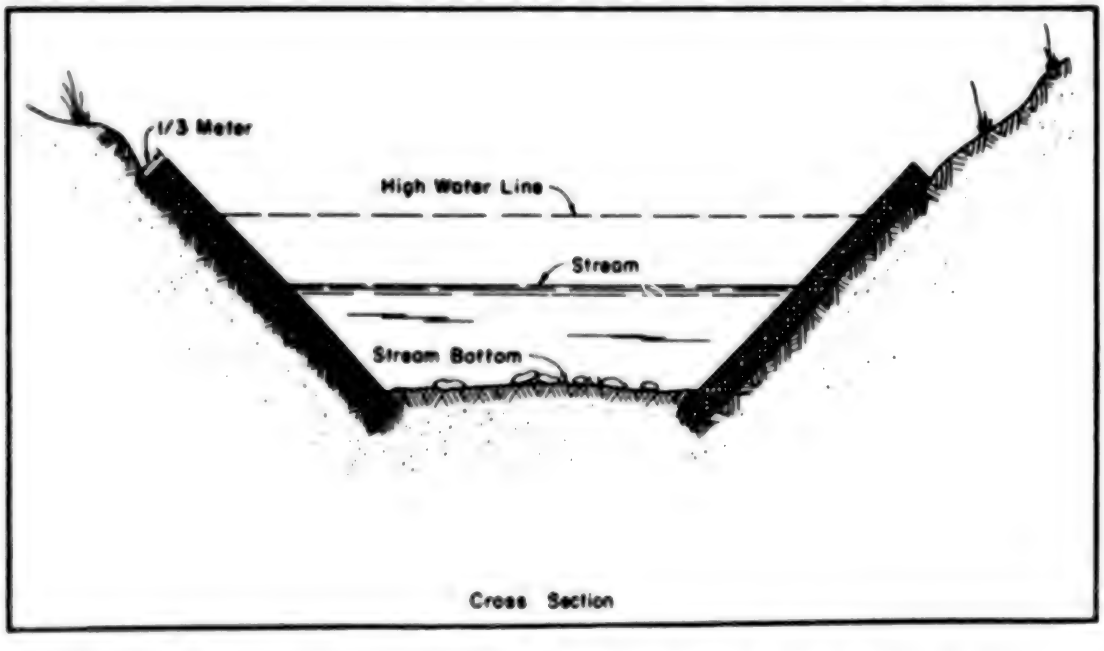


Figure 3.3-7. Stream cross section showing the use of gabion mats on a sloping streambank (from Nelson et al. 1978).

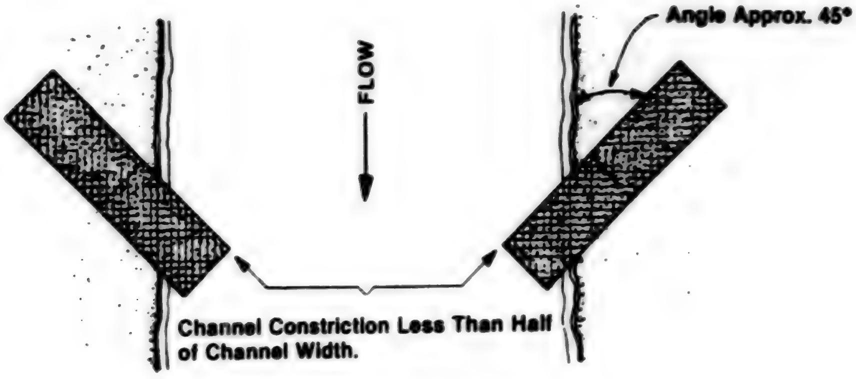
Figure 3.3-8. Placement of stone gabions to protect a streambank (from U.S. Forest Service 1969).

Riprap is less expensive than gabion matting. In this case, large rocks are piled along the bank to help prevent erosion (Figure 3.3-11). The rock should be large enough to prevent silting of intervening spaces which provide fish habitat. Use of riprap is common along roads, and specifications should comply with road building codes.

In addition to artificial protective structures, the planting of additional vegetation will provide increased stabilization of the shoreline. Various species of willow are commonly used (U.S. Forest Service 1969). Grasses and shrubs provide additional stability. As a general rule, native species are best used since they are adapted to the area. Proven exotic species may be beneficial in some cases to provide added food and cover, but local experts in agencies such as the Soil Conservation Service should be consulted to determine the most suitable species and their availability.

## MAINTENANCE AND MANAGEMENT

Gabion mats, deflectors and riprap are considered temporary and should not be expected to replace the need for revegetation of a streambank. In cases where bank stabilization is a serious problem, however, these techniques can provide the additional protection necessary for vegetation to become reestablished. Depending on the site, stream siz . and degree of erosion, the need for replacement of gabions or riprap will vary.



**DOUBLE DEFLECTORS**

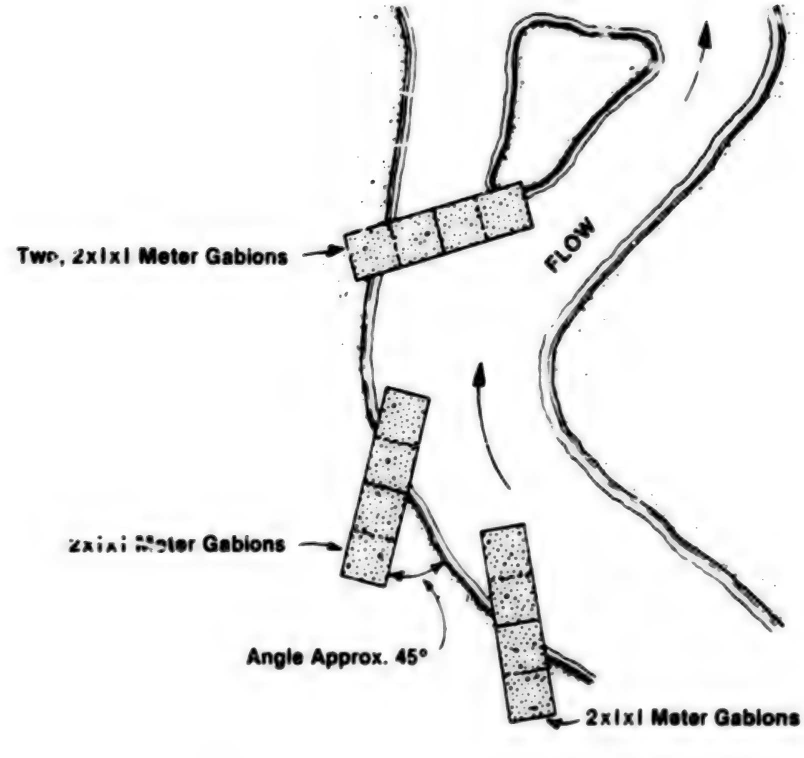


Figure 3.3-9. Examples of the use of a combination of gabion deflectors (from U.S. Forest Service 1969).

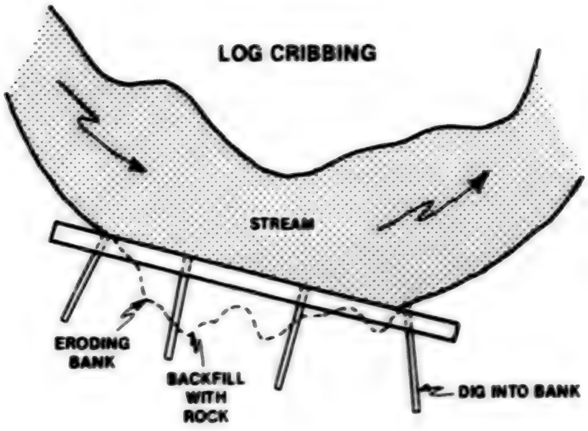


Figure 3.3-10. A diagram demonstrating the use of log cribbing for streambank protection (from West Virginia Department of Natural Resources, no date).

## LABOR/MATERIALS

Cost, man-hours, equipment needs, and materials will vary with site-specific characteristics. Use of riprap is cheaper than gabions, but depends on the availability of the proper-sized stone. Hauling stone long distances can significantly affect the price. Gabions require the use of wire mesh and, therefore, require the added cost of the construction labor. Placing the rocks in the wire cages by hand (as recommended) may also incur labor cost.

Generally, the price of dumped stone rip-rap averages around $31 per cubic meter ($24 per cubic yard). Stone filler for gabion mats runs approximately $31 per cubic meter ($24 per cubic yard) but can range from $18 to $59 per cubic meter ($14 to $45 per cubic yard). Wire mesh for constructing gabions varies in price based on mesh size and wire gauge but can range from $5 to $16 per meter ($1.50 to $5 per linear foot).

The cost of revegetation will vary according to the size of the area, the species used, and local labor costs.

## SOURCES OF INFORMATION

More information on the protection and maintenance of streambanks can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency
- State Highway Department
- U.S. Forest Service
- U.S. Army Corps of Engineers

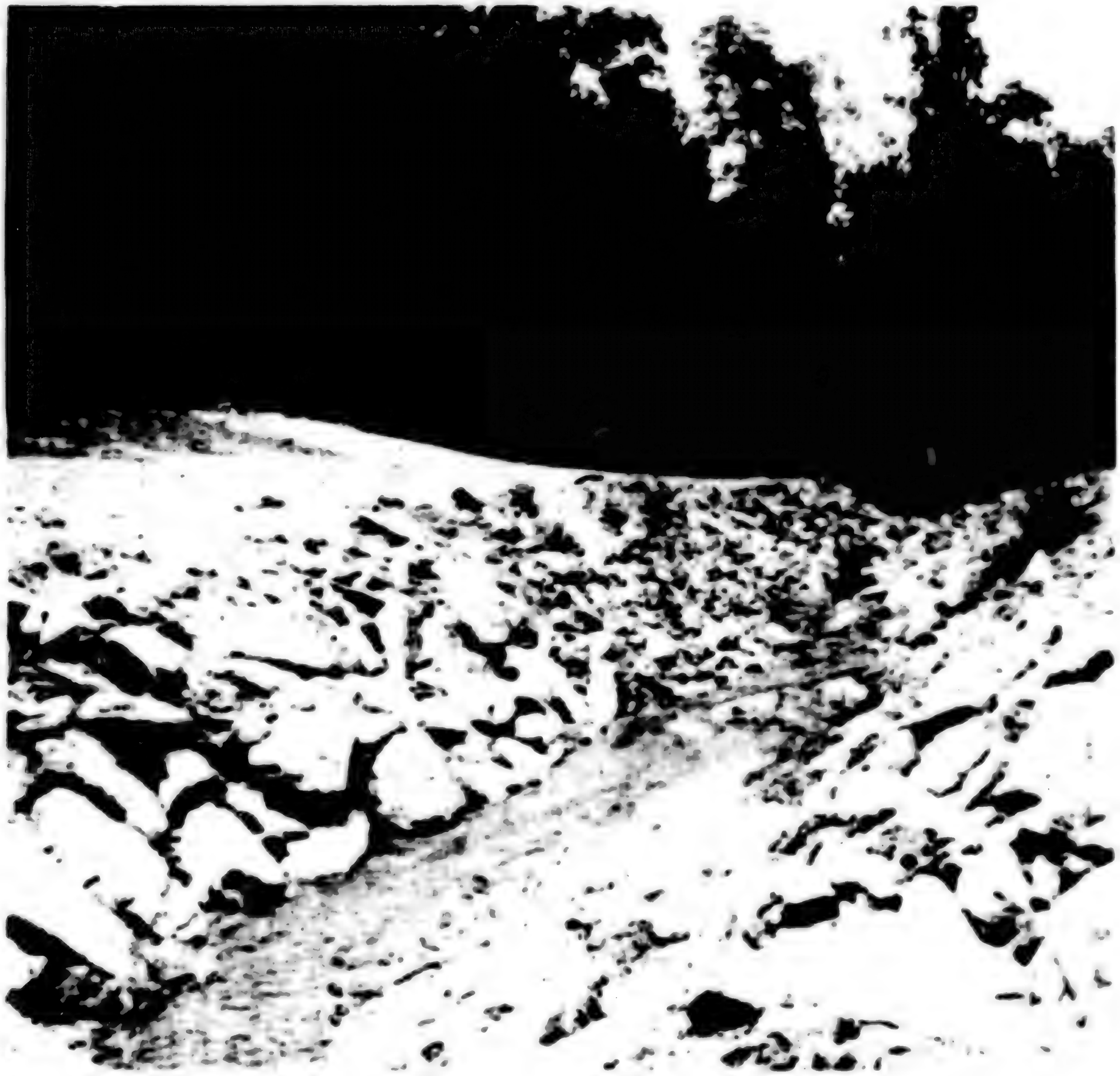


Figure 3.3-11. Use of riprap to protect a streambank from erosion (U.S. Environmental Protection Agency 1976).

References cited:

Nelson, R. W.; Horak, G. C.; Olson, J. E. Western reservoir and stream habitat improvements handbook. U.S. Fish and Wildlife Services. FWS/OBS-78/56; October 1978.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; August 1969.

U.S. Environmental Protection Agency. Erosion and sediment control -surface mining in the Eastern U.S. Technology Transfer, EPA-625/3-76-006; October 1976.

West Virginia Department of Natural Resources. Stream improvement guide. Charleston, WV: Division of Wildlife Pamphlet; no date.

Additional references:

Keown, M. P.; Oswalt, N. R.; Perry, E. B.; Dardeau, E. A., Jr. Literature survey and preliminary evaluation of streambank protection methods. U.S. Army Corps of Engineers Waterways Experiment Station, Hydraulics Laboratory, Mobility and Environmental Systems Laboratory, Soils and Pavement Laboratory, Technical Report H-77-9; May 1977.

### c. Final cut lakes as permanent impoundments.

Four of the six States in the central and southern Appalachia coal region (Alabama, Georgia, Kentucky, and Tennessee) have historically had final cut lakes left as permanent impoundments. Recently however, Federal and State regulations began limiting the retention of this type of impoundment on reclaimed surface mines. The objective of the final cut regulations were to return the cut to its approximate original contour with all highwalls, spoil piles and depressions eliminated. An operator may be able to get a variance from approximate original contour, but only for mountaintop removal operations or steep slope mining. A permanent impoundment can be formed in the final cut if the landowner agrees, the highwall is reclaimed, and certain standards regarding water quality and level are met. A land-use change must be approved by the regulatory authority if no pond was there before mining.

Various uses of final cut lakes have been proposed, including recreation, livestock watering, irrigation or community water supply, and fish and wildlife use. Problems arise when trying to determine the design criteria which should be met in order for the final cut lake to be practical in its postmining land use objective. A study is now underway, funded by the Office of Surface Mining (OSM), to assist operators with these and other problems associated with final cut lakes (Nelson et al. 1982). This manual is expected to address many of the problems associated with final cut lakes and set recommendations on design criteria and management of proposed permanent impoundments. Because of the comprehensive and definitive nature of this study, it is recommended that operators obtain a copy of this publication prior to considering the use of final cut lakes as permanent impoundments. Information on this manual can be obtained by writing the following address:

Assistant Director for Technical Services and Research
Office of Surface Mining
1951 Constitution Ave., N.W.
Washington, DC 20240

Reference cited:

Nelson, R. W.; J. F. Osborn; W. J. Logan. Planning and management of mine cut lakes at surface coal mines. Washington, DC. U.S. Dept. of Int., Office of Surface Mining. OSM TR-82/1. 1982.

### d. Fish stocking.

### PURPOSE

A well-stocked permanent fish pond is a valuable asset to any landowner. Even if the pond is managed primarily for fish production, these ponds can also provide recreational swimming, picnicking along the shore, and water for wildlife. Sale of fishing rights can also provide an added source of income. Stocking, however, is more than just putting fish in a pond. Several factors are discussed below which can lead to very successful fish production.

### ILLUSTRATION

Basically, two types of fish ponds are possible in the central and southern Appalachians: warm-water or cold-water (trout) ponds. Figure 3.3-12 illustrates the geographic area where trout ponds can be managed. The cold-water fishery is more likely to be successful where cold-water springs or wells constantly replenish the water so that the summer water temperature is 21°C (70°F) or less (Marriage et al. 1976). However, the range of trout ponds may be extended where there is a good source of cold water year-round. On the other hand, warm-water fisheries are successful where the summer water temperature reaches between 27°C (80°F) and 32°C (90°F) (Dillon et al. 1977). The pH and other water quality characteristics are very important in determining the success or failure of the establishment, growth, and management of the introduced fish populations. The preferred kinds, combinations, and number of fish for stocking in such ponds are discussed below.

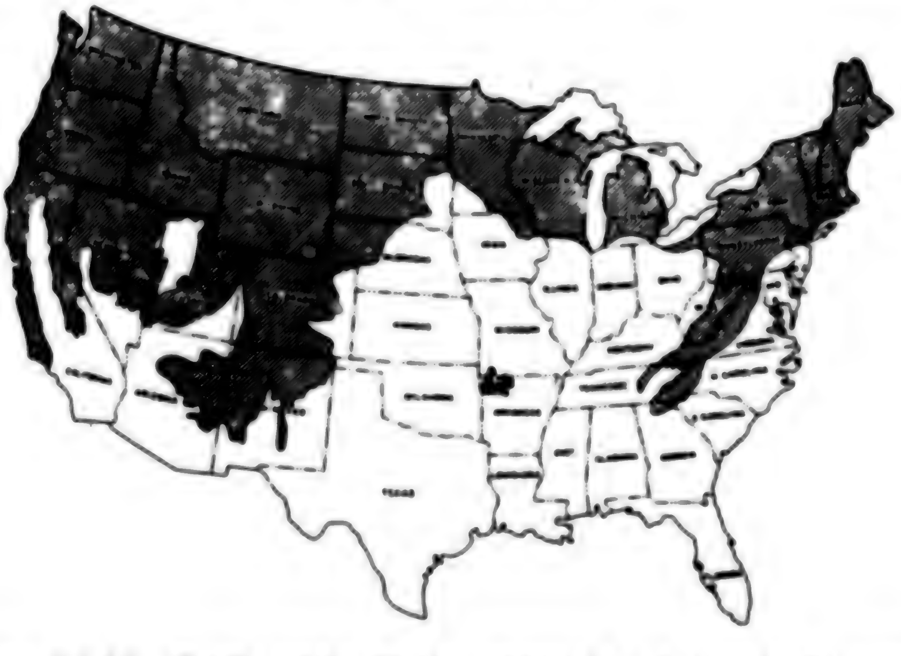


Figure 3.3-12. Trout ponds may be successful in the shaded area (from Marriage et al. 1976).

## Warm-Water Fishery

Warm-water ponds can be managed for largemouth bass, bluegill and redear sunfish, catfish (channel or bullhead), or bait minnows. The pond to be stocked should be clear of wild fish prior to stocking. This can be accomplished by either draining the pond or using chemical killing agents. The supervision of a State game and fish agent or Soil Conservation Service (SCS) State conservationist is highly advised during the removal.

The size and number of fish will depend on the combination of species and the surface area of the pond. It is very important to know the correct pond size (preferably within 0.04 hectare [0.1 acre]). If the size of the pond is underestimated, too many fish will be ordered and very few will grow to desirable sizes. On the other hand, if the size of the pond is overestimated, a few fish will grow large, and, in the case of bass and bluegill, bluegill will overpopulate in a short time (Cobb 1970).

Stocking rates of fertilized and unfertilized ponds differ; therefore, this should be considered when determining the number of fingerling (i.e., young fish) needed for stocking a pond. It is not good practice to stock mature fish from other ponds in the area. Always stock the recommended number, type, and size of fish, and perform the stocking in the season recommended by local, State, and/or Federal hatcheries. In many cases, free fish are available from these hatcheries, and applications may be obtained from offices of the game and fish agency or from the SCS.

When the fish are available to be picked up, follow hatchery directions as closely as possible in transporting the fingerlings. A clean container is an absolute must for transporting.

Some special considerations are in order for certain species or species groups:

> Bass and bluegills - Ponds with average fertility can be stocked at a rate of 50 bass and 500 bluegills per 0.4 hectare of surface area (per surface acre), while ponds with high fertility can be stocked with 100 to 150 bass and 1,000 to 1,500 bluegills per 0.4 hectare (1 acre). Redears may be included at the above rates as a substitute for one-third of the bluegills. If water is overflowing during the time of stocking, a temporary screen will prevent fingerling loss. However, the screen should be removed 10 days after stocking (Dillon et al. 1977).
>
> Channel catfish - In a bass-bluegill pond, 100 to 200 catfish per 0.4 hectare of surface area (per surface acre) may be used if they are about the same size as the bass and are stocked at the same time (Dillon et al. 1977). Basically, the number of fish stocked depends on the size desired at the end of the growing [illegible]. Fingerlings that measure 10 to 15 cm (4 to 6 inches) reach 0.5 kg (1 pound) average weight in 210 days when stocked at 1,500 per 0.4 hectare of pond surface area (surface acre). Larger fingerlings (25 cm [10

inches]), stocked at 1,200 per 0.4 hectare of pond surface area (surface acre), average 0.9 kg (2 pounds) at the end of the growing season. Rates vary considerably, but some rules of thumb are:

- 750 to 1,000 fish per 0.4 hectare of pond surface area (surface acre) (10 to 15 cm [4 to 6 inches]) in runoff impoundments where aeration is not practiced.
- 1,500 to 2,000 fish (10 to 15 cm [4 to 6 inches]) per 0.4 hectare of pond surface area (surface acre) in ponds with a constant water supply.
- 1,200 fish (25 cm [10 inches]) per 0.4 hectare of pond surface area (surface acre) with constant water supply.
- 700 to 800 fish (2 years old or 0.22 kg [0.5 pound]) per 0.4 hectare of pond surface area (surface acre) with constant water supply.
- 3,500 to 5,000 fish (10 to 15 cm [4 to 6 inches]) per 0.4 hectare of pond surface area (surface acre) where water flows through at the rate of approximately 570 liters (150 gallons) per minute (Grizzell et al. 1975).

Channel catfish rarely spawn in fish ponds without proper facilities. Periodic restocking is necessary and generally easier than preparing the facilities.

Bullhead catfish - These fish spawn well in bass-bluegill ponds, but need cover for escape. If they are too well protected, they may overpopulate the pond. In heavily managed ponds, bullheads may be stocked after the spawning season, fed during the winter, and harvested the following spring (Dillon et al. 1977).

Israeli carp - Carp stocking may be prohibited by some States, but they can successfully be used to control algae growth where permitted. Fingerlings placed in bass ponds should be greater than 13 cm (5 inches) to prevent predation by bass and should be stocked at 25 to 50 per 0.4 hectare of surface area (surface acre) (Dillon et al. 1977).

Crappie - Low summer water levels and high winter levels are necessary for production of this species. They are stocked at a rate of 25 fingerlings of crappie with 50 to 100 largemouth bass per 0.4 hectare of surface area (surface acre) (Dillon et al. 1977). They are not often recommended for farm ponds due to the need to manage the water level.

**Bait fish** - Expert consultation is needed for production methods here. The SCS fisheries biologist can provide assistance.

### Coldwater Fishery (Trout Ponds)

Generally, trout are not stocked with other fish because they do not respond well to competition. Rainbow and brook trout are available for stocking and are often stocked together. Water quality, pH, surface area and fish size determine the ability of a pond to support these fish. In the central and southern Appalachians, stocking rates average around 600 (8- to 10-cm [3- to 4-inch]) fish per 0.4 hectare of surface area (surface acre). They are stocked in the fall and reach 0.2 kg (8 ounces) the first year. Every 2 years, 10- to 13-cm (4- to 5-inch) fingerlings are restocked under normal fishing conditions to maintain the population since they generally do not reproduce in an impoundment.

Trout are very sensitive to sudden changes in water temperature and chemistry. With this in mind, they should never be placed directly into pond water from the shipping container. They should also never be stocked at water temperatures less than 18°C (65°F). When transferring the fingerlings, slowly dilute the shipping water with pond water until temperatures of the containers and the pond are within 14°C (6°F). Then allow fingerlings to escape by slowly submerging the container into the pond (Marriage et al. 1976).

Trout stock is not generally available without charge. State game agents or SCS personnel can assist in finding distributors within a particular State. In some states, the Fish and Wildlife Service may provide stocking material to public access ponds.

## MAINTENANCE AND MANAGEMENT

Restocking depends on the fish species, pond characteristics, fishing pressure and fish health. Pond management, including fertilization and pest control, are discussed in other sections. It is best to discuss your plans with a State Conservationist who can help you set up a management plan.

## LABOR/MATERIALS

Although free fish for stocking are no longer available from government agencies, the State Fish and Game Departments can provide a list of commercial hatcheries where fingerlings can be purchased.

## SOURCES OF INFORMATION

In many cases, free information on fish stocking is available through government agencies within a State. Below is a list of appropriate contacts to make in southern and central Appalachia:

Alabama - Extension Fisheries Specialist
State Extension Services
Auburn University
Auburn, AL 36830
(205) 826-4786

Division of Game and Fish
Department of Conservation and
Natural Resources
64 N. Union St.
Montgomery, AL 36130
(205) 832-6300

Soil Conservation Service*
Wright Building
138 South Gay Street
P.O. Box 311
Auburn, AL 36830
(205) 821-8070

Georgia - Extension Fisheries Specialist
State Extension Services
University of Georgia
Athens, GA 30602
(404) 542-3824

Game and Fish Division
Department of Natural Resources
270 Washington Street,
Southwest
Atlanta, GA 30334
(404) 656-3530

Soil Conservation Service*
Federal Building
355 E. Hancock Avenue
P.O. Box 832
Athens, GA 30603
(404) 546-2274

Kentucky - Superintendent, Fish Hatchery
Department of Fish and
Wildlife Resources
Rt. 4
Morehead, KY 40351
(606) 784-6872

Director, Division of
Fisheries
#1 Game Farm Road
Frankfort, KY 40601
(502) 564-3596

Soil Conservation Service*
333 Waller Avenue
Lexington, KY 40504
(606) 233-2749

Tennessee - Tennessee Wildlife Resources
Agency
Box 153A
Talbott, TN 37877
(800) 332-0900 (Toll Free)

Soil Conservation Service*
675 U.S. Courthouse
Nashville, TN 37203
(615) 749-5471

Virginia - Extension Fisheries Specialist
State Extension Services
Virginia Polytechnic Institute
and State University
Blacksburg, VA
(703) 961-5059

Commission of Game and Inland
Fisheries
4010 W. Broad Street
Box 11104
Richmond, VA 23230
(804) 257-1000

Soil Conservation Service*
Federal Bldg., Room 9201
400 N. 8th Street
P.O. Box 10026
Richmond, VA 23240
(804) 782-2457

West Virginia - Assistant Chief, Fish
Management
Department of Natural
Resources
1800 Washington St., East
Charleston, WV 25305
(305) 348-2771

Soil Conservation Service*
75 High St.
P.O. Box 865
Morgantown, WV 26505
(304) 599-7151

*In addition to regional offices, local SCS offices, listed in the telephone directory, can provide guidance on fish pond development and stocking.

References cited:

Cobb, E. S. The management of Tennessee farm ponds. Nashville, TN: Tennessee Game and Fish Commission; 1970.

Dillon, O. W., Jr.; Neely, W. W.; Davison, V. E.; Compton, L. V. Warm-water fish ponds. Washington, DC: USDA Farmers Bulletin No. 2250. U.S. Gov't. Printing Office; 1977.

Marriage, L. D.; Borell, A. E.; Scheffer, P. M. Trout ponds for recreation. Washington, DC: USDA Farmers Bulletin No. 2249. U.S. Gov't. Printing Office; 1976.

Additional references:

Borell, A. E.; Scheffer, P. M. Trout in farm and ranch ponds. Washington, DC: USDA Farmers Bulletin No. 2154; 1961.

Burner, C. C. Fishery management in strip-mine lakes. In: Research and Applied Tech. Symposium on Mined Land Reclamation. Pittsburgh, PA; 1973:304-318.

Davies, W. D. Managing small impoundments and community lakes. In: Proceedings of the 27th Annual Conference of the Southeastern Association of Game and Fish Commissioners (reprint); 1973:347-355.

Fox, A. C. Development and impoundment of drastically disturbed surface-mined land for fishing. In: Symposium on Rehabilitation of Drastically Disturbed Surface Mined Land. Georgia Surface Mined Land Use Board. Macon, GA; 1971:109-111.

Grizzell, R. A., Jr.; Dillon, O. W., Jr.; Sullivan, E. G.; Compton, L. V. Catfish farming. Washington, DC: USDA Farmers Bulletin No. 2260. U.S. Gov't. Printing Office; 1975.

Hatcher, R. M. Catfish farming in Tennessee. Nashville, TN: Tennessee Wildlife Resources Agency; 1977.

Swingle, H. S. Biological means of increasing productivity in ponds. Auburn University Agricultural Experiment Station. In: Proceedings FAO World Symposium on Warm-Water Pond Fish Culture. Rome, Italy; 1966.

U.S. Fish and Wildlife Service. Farm fish ponds and their management. Washington, DC: Fishery Leaflet No. 27; no date.

Whitwell, T.; Bayne, D. R. Weed control in lakes and farm ponds. Circular ANR-48. Alabama Cooperative Extension Service; no date.

### e. Pond fertilization for fish management.

## PURPOSE

Pond fertilization with commercial fertilizers (N-P-K) can be used to increase fish production and to control aquatic weeds. Fertilizer added to a pond increases plankton algae production, which ultimately increases the food base available to the fish. This desirable algae growth does not include the troublesome filamentous algae. Increased algae growth also shades out most types of submerged aquatic weeds and suppresses the growth of many emergent plants. Weed control provides easier feeding for game fish and easier fishing and fish management for the pond owner. Fertilizer may also cause clay particles to settle out of muddy water.

## DEVELOPMENT

New ponds should be fertilized as soon as they fill with water. This will develop a good food base for fish and control the growth of aquatic weeds. Once started, fertilization of a pond should be continued as long as the pond is managed for fish. A pond with low total water hardness (below 10 to 15 ppm) or an acid condition should be treated with lime before fertilizer is added (U.S. Forest Service 1969). These conditions inhibit the fertilizer from being fully utilized in a pond. To increase water hardness, hydrated lime can be applied at 45.4 kg per 0.4 hectare of surface area (100 pounds per surface acre), or agricultural lime may be used at 450 to 900 kg per 0.4 hectare (1,000 to 2,000 pounds per acre). Acidic water should be treated with lime until the pH is at a level suitable for the species of fish to be stocked.

Most ponds require about 10 or less applications of fertilizer each year (Dillon et al. 1971). Applications should begin in early spring and continue through late fall. Commercial fertilizer should be applied at the following rates per 0.4 hectare of surface area (surface acre) (Cobb 1970):

45.4 kg (100 pounds) of 8-8-2, or
22.7 kg (50 pounds) of 16-16-4 or 15-15-15, or
18.2 kg (40 pounds) of 20-20-5.

The easiest way to apply fertilizer is from a pallet-like platform placed about 0.3 hectare (12 inches) below the water surface near the pond edge. Fertilizer sacks are placed on the platform and slit open, letting wave and current action mix the fertilizer into the pond. One platform can be used to treat up to 6.1 hectares (15 acres) of surface area. A floating platform can be used in ponds with fluctuating water levels. Fertilizer can also be applied by broadcasting it from the bank or from a boat in areas no deeper than 0.9 or 1.2 meters (3 or 4 feet).

Determination of how often to fertilize a pond can be made with the aid of a simple measuring instrument (Dillon et al. 1971). A white disk a few centimeters in diameter is fastened to the end of a 0.9-meter-long (3-foot-long) stick marked at 0.3- and 0.5-meter (12- and 18-inch) intervals above the disk. To check pond fertility, the disk is placed in the water with the stick held upright. If the disk is visible at a depth of 0.5 meter (18 inches) or more (marked on the stick), an application of fertilizer is needed. A color change in the water should be detectable in 3 to 7 days after fertilizer is added. Water color may be any shade of green or brown, depending on the types and number of algae present. When the disk is out of sight between 0.3 and 0.5 meter (12 and 18 inches) deep, the pond is productive enough to support up to 180 kg of fish per 0.4 hectare of surface area (400 pounds per surface acre) and needs no fertilizer at that time. The first few applications in the spring may be needed as often as every 10 days.

A more simple, but probably less efficient, fertilizing schedule is two applications during the first month of spring, followed by a monthly application through late fall (Cobb 1970).

## MAINTENANCE AND MANAGEMENT

Fertilization of a pond does not always improve fishing. Proper fish population management techniques should be used together with fertilization to maintain a healthy, productive pond. Fertilization of an overpopulated pond will produce more pounds of fish, but generally the average size of the fish will not increase appreciably. Management recommendations should be obtained from a local fisheries biologist.

Aquatic weed and filamentous algae control may become necessary if these plants begin to crowd the pond. Submerged and emergent vegetation can be controlled with commercial herbicides when used under the direction of a fisheries biologist. Many herbicides are extremely toxic to fish in very small amounts, and manual removal of vegetation is usually not effective, especially in large ponds. Ponds with most areas at least 0.9 meter (3 feet) deep have fewer weed problems than ponds with extensive shallow areas. Filamentous algae can be controlled by applying copper sulfate crystals directly on the algal mats at a rate of 1.4 kg per 93 square meters (3 pounds per 1,000 square feet). Use of commercial fertilizers in a pond does not encourage the growth of filamentous algae as do organic fertilizers such as manure, cottonseed meal, or leaves.

## LABOR/MATERIALS

The labor and materials necessary to fertilize a pond for improved fish production are minimal. The fertilizer itself is the only essential material and averages 10 applications or less of fertilizer per 0.4 hectare of surface area (surface acre) per year. If platforms are used for application, scrap hardwood lumber from a pallet or crate can provide the needed material. The labor involved in building and placing a platform should be no more than a few hours. The labor required for fertilizing a pond includes about 12 visits to a pond each year. The length of time necessary for each visit depends on the size of the pond and the need for weed control activities. For ease of application, the amount of fertilizer necessary for a pond for one year can be stored near the pond, either on pallets under a plastic sheet or in a small shed.

## SOURCES OF INFORMATION

Recommendations and advice on pond fertilization can be obtained from a fisheries biologist. A fisheries biologist can be contacted in private industry or at one of the following State or Federal agencies:

- U.S. Fish and Wildlife Service
- Soil Conservation Service
- State Fish and Game Agency

References cited:

Cobb, E. S. The management of Tennessee farm ponds. Nashville, TN: Fish Management Division. Tennessee Game and Fish Commission; 1970.

Dillon, O. W., Jr.; Neely, W. W.; Davison, V. E.; and Compton, L. V. Warm-water fishponds. Soil Conservation Service. Farmers' Bulletin No. 2250; 1971.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

Additional references:

Davies, W. D. Managing small impoundments and community lakes. In: Proceedings of the 27th Annual Conference of the Southeastern Association of Game and Fish Commissioners; 1973.

Swingle, H. S. Fertilizing farm fish ponds. Agricultural Experiment Station of Auburn University. Highlights of Agricultural Research 12(1):11; 1965.

### f. Fish shelters in pond and lakes.

## PURPOSE

Fish shelters provide cover, feeding habitat, and spawning areas for game and forage fish. In warm-water ponds and lakes, they tend to attract and concentrate fish, making recreational fishing more productive. Brush shelters, tire shelters, and culvert shelters (Figure 3.3-13) are considered most effective by fisheries biologists (U.S. Fish and Wildlife Service 1978). Other structures are available for use, but they are, in most cases, more expensive to construct.

## DEVELOPMENT

### Brush Shelters

Brush shelters can be as simple as a single tree pushed over into the water (Figure 3.3-13) or as complicated as a small log house (Figure 3.3-14). Whatever design is used, durable hardwoods and cedar produce shelters that will last many years (U.S. Forest Service 1969).

A single tree, pushed over into the water, provides excellent cover for bass. Most of the top should be removed, and the tree should be left anchored by its roots (Figure 3.3-13).

Small, submerged brushpiles are most easily constructed before a pond is filled or during a drawdown. Brush is gathered into a 3.1- to 6.2-meter (10- to 20-foot) diameter pile, tied together with wire or cable, and anchored or weighted to keep it in place. Screw-type power pole cable anchors make excellent tie-downs. Brushpiles should be placed in 3.1 to 6.2 meters (10 to 20 feet) of water and about 45.7 meters (150 feet) apart (U.S. Forest Service 1969).

In large ponds or final-cut lakes, large brushpiles 9.1 to 12.2 meters (30 to 40 feet) in diameter or long windrows can be created from slash (U.S. Fish and Wildlife Service 1978). While effective and easy to build with heavy equipment, large brushpiles and windrows are difficult and time-consuming to anchor. The water depth and distance recommendations, however, are the same as for smaller brush shelters.

### Tire Shelters

Discarded tires, bound together with wire or cable, weighted, and sunk, make excellent, long-lasting shelters. For small ponds, three tires wired together in a triangle produce effective shelters (Figure 3.3-13). The tires are weighted with rocks so the structure will remain upright when sunk. Slashing the tires prevents air from being trapped. Structures as large as desired can be formed by adding more tires in any configuration that maximizes the size and number of spaces between tires (Figure 3.3-15).

On pond and lake bottoms that lack sand or gravel beds, tires can be used to create spawning beds for largemouth bass (Figure 3.3-13). Before the pond or lake is filled, tires are placed on their side in areas where the water will be 0.6 to 1.2 meters (2 to 4 feet) deep and then filled with sand or gravel. Large-diameter equipment tires are best for this purpose. Although spawning beds can also be constructed by creating gravel beds (3.1 to 4.6 meters in diameter [10 to 15 feet]), the use of tires prevents the gravel from becoming silted over.

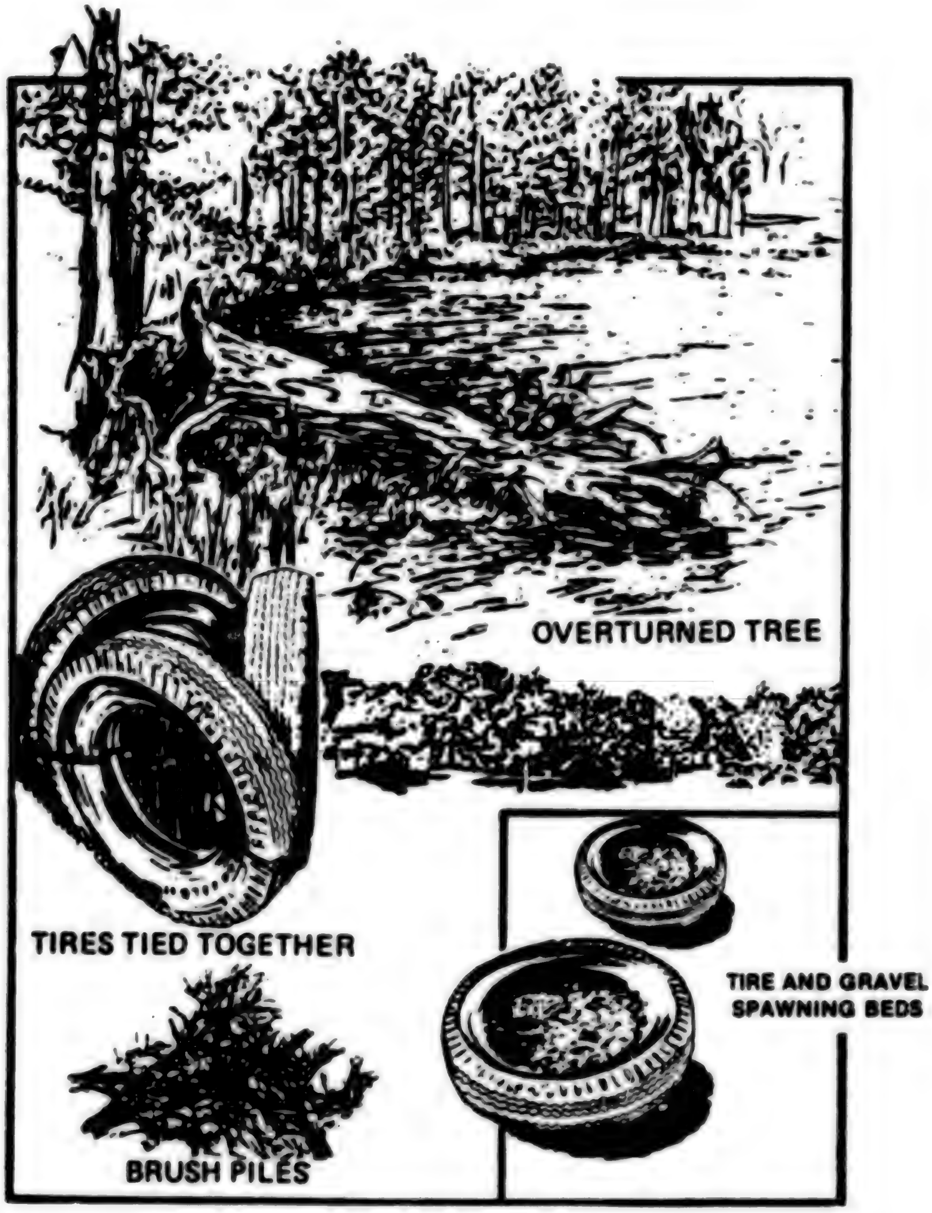


Figure 3.3-13. Simple, effective types of fish shelters (from Inman 1976).

Figure 3.3-14. Brush shelter under construction (from Cobb 1980).

## Culvert Shelters

Natural reproduction of channel and other catfish can be encouraged by providing artificial spawning structures in the form of culvert shelters. Small-diameter (20- to 30-cm [6- to 12-inch]) concrete or corrugated metal culverts or clay drain tiles are suitable as shelters when placed in 2 to 4 feet of water (Figure 3.3-16). Best results are obtained when one end of the culvert is closed by filling with 8 to 10 cm (3 to 4 inches) of concrete or by burying one end in the pond bottom. The open end should then be placed at a slight upward angle to avoid trapping air inside the culvert. On steep bottoms, the culverts should be half-buried, leaving the open end protruding from the sloping bottom.

Figure 3.3-17 shows the placement of several types of fish shelters in a pond approximately 2 hectares (5 acres) in size. Relocating or changing the number or types of shelters in a pond would depend on the size, shape, and depth of the impoundment. Assistance on the placement of these structures can be obtained from agencies listed under Sources of Information below.

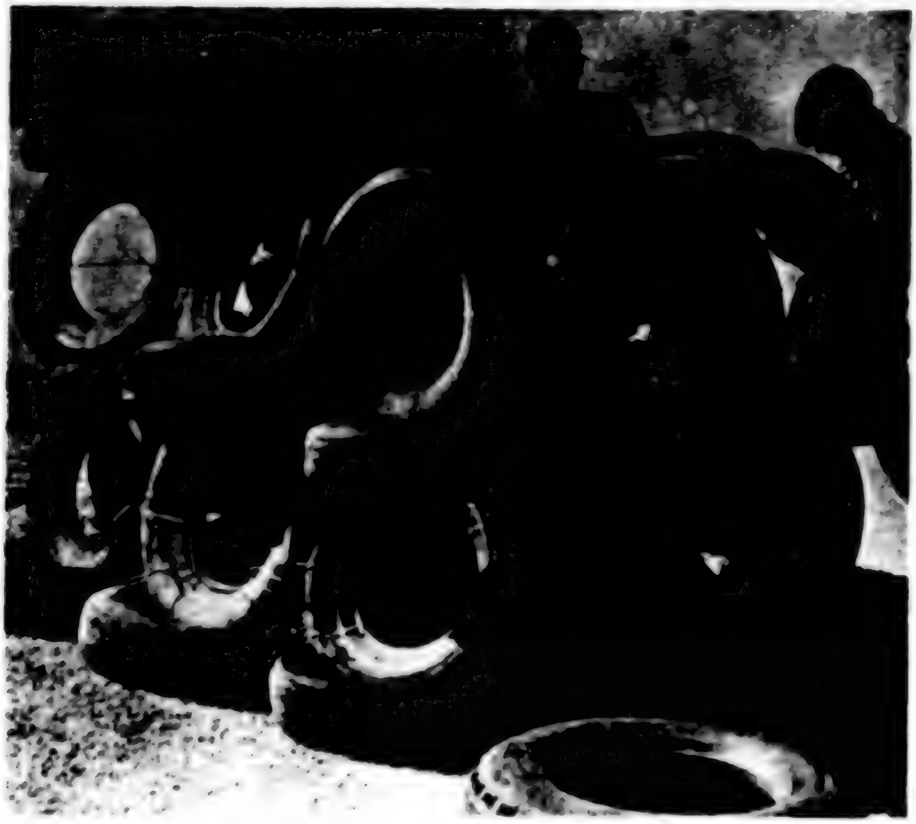


Figure 3.3-15. A large tire shelter (from U.S. Fish and Wildlife Service 1978).

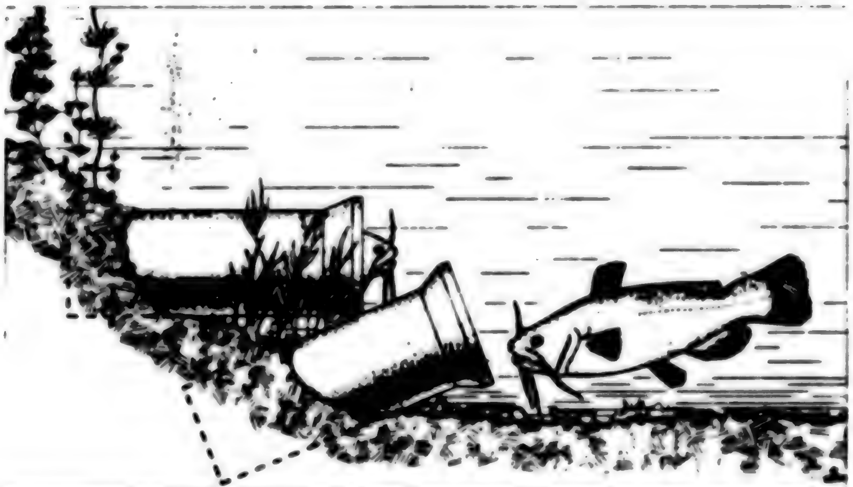


Figure 3.3-16. Catfish spawning shelters (from U.S. Fish and Wildlife Service 1978).

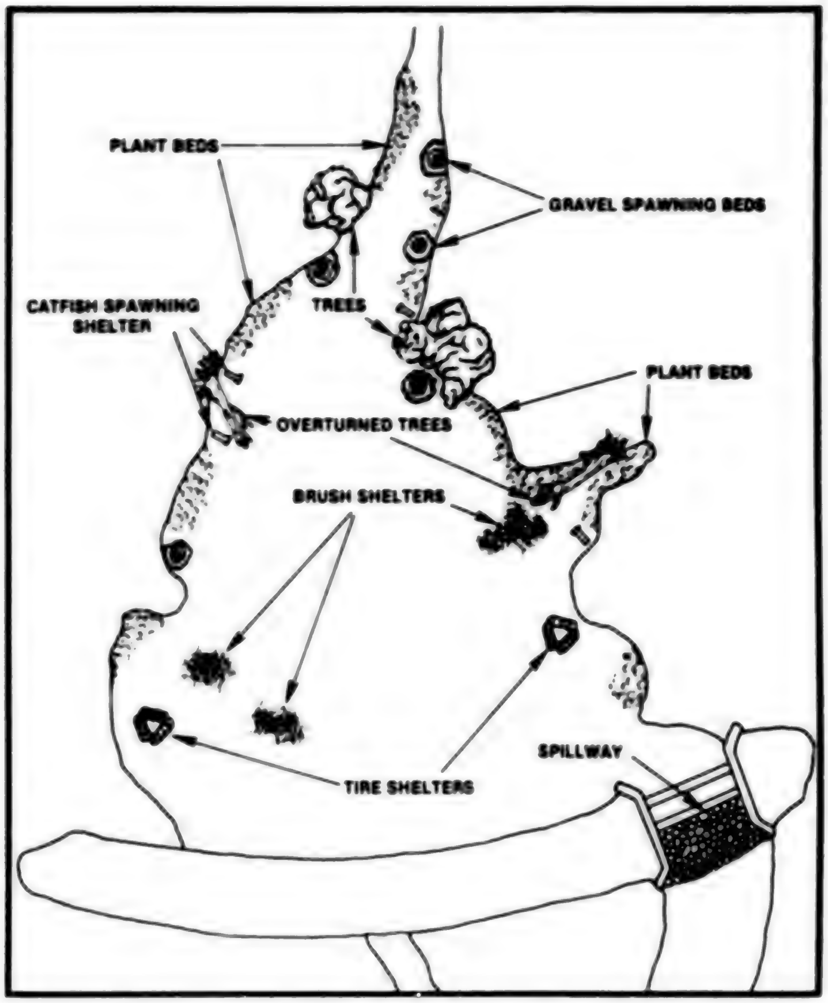


Figure 3.3-17. Placement of fish shelters in a pond (after Inman 1976).

## MAINTENANCE AND MANAGEMENT

Once constructed, fish shelters require no maintenance. Replacement of brushpiles and other wooden structures may become necessary after a number of years due to deterioration.

## LABOR/MATERIALS

Each type of simple fish shelter requires one to three man-hours or less to construct and install. More elaborate structures will require considerably more time. All the materials needed for constructing fish shelters are readily available as salvage material from most mining operations. Logs, brush, discarded tires, bits of wire and cable, and cracked or broken culverts produce excellent fish shelters with proper planning and construction. Although these materials are sometimes discarded after a mining operation, a pond should not be used as an indiscriminate dumping ground. Shelter materials should be placed within the pond with careful consideration of the fisheries management objectives.

## SOURCES OF INFORMATION

A fisheries biologist can provide assistance in determining the fish shelter needs for a specific pond or lake. The following agencies can provide personnel for assistance:

- o State Fish and Game Agency
- o U.S. Fish and Wildlife Service
- o Soil Conservation Service
- o State University Extension Service

References cited:

Cobb, E. S. The management of Tennessee farm ponds. Nashville, TN: Tennessee Wildlife Resources Agency; 1980.

Inman, C. R. Construction and preliminary management practices for new ponds and lakes. Austin, TX: Texas Parks and Wildlife Department; 1976.

U.S. Fish and Wildlife Service. Western reservoir and stream habitat improvement handbook. FWS/OBS-78/56; 1978.

U.S. Forest Service. Wildlife habitat improvement handbook. FSH 2609.11; 1969.

g. Creation of impoundments for waterfowl.

PURPOSE

A great number of waterfowl of many species migrate through the Appalachian region in the fall to overwinter further south and in the spring to establish breeding territories further north. The wood duck is the only duck which nests regularly in the central and southern Appalachians, while other species, such as the mallard, blue-winged teal, American coot, and pied-billed grebe, are common winter residents. The areas which these ducks need for feeding, nesting, and for cover is rapidly disappearing due to channelization of waterways, filling of wetlands, and clearing of hardwood swamps. Small impoundments on strip-mined sites can offer significant benefits to local waterfowl populations by providing the food, cover, and shelter which otherwise may be unavailable.

DEVELOPMENT

Most State surface mine regulations require that impoundments constructed on the permit area be removed if designed as temporary structures, or can be allowed to remain if designed as permanent structures where no hazards exist. The overall structural design of an impoundment which is allowed to remain on a mine site after mining will have to be approved by the regulatory authority. Several factors, listed below, will influence their decision:

- the potential safety hazard of an impoundment dam failing during a heavy rainfall. This could result in the flooding of downstream communities and/or the release of sediments or toxic materials.
- the postmining land use objective. If an impoundment for waterfowl use is proposed for a reclaimed area, then the impoundment should be compatible with the postmining land use. For example, some types of industrial development are not very compatible with wildlife use.
- the appropriate measures taken to make the impoundment attractive to fish and wildlife. An impoundment which is not "enhanced" by suitable plantings or which is not designed properly will also be of marginal value to wildlife.

Several publications have been written which discuss the design criteria for impoundments for waterfowl in the Appalachians (Almand 1971, Anderson 1975, Beshears 1974, Dewberry no date). They emphasize the use of beaver ponds, "green-tree" reservoirs, and seasonal feeding ponds as waterfowl use areas. Seasonal feeding ponds (Figure 3.3-18) come the closest of all three types to the kind of impoundment most appropriate for waterfowl on reclaimed surface-mined areas.

Seasonal feeding ponds are characterized as being impoundments located in open drainage areas which are adequately supplied with water and have good soil nearby to support the growth of food plants (Beshears 1974). Open water areas should be at least 0.1 hectare (0.25 acre) in size and preferably 4.1 hectares (10 acres) or more. In general, the larger the impoundment, the better the opportunity for attracting waterfowl. Depths of the impoundment should also be no greater than 0.5 meters (18 inches) to allow diving ducks access to food.

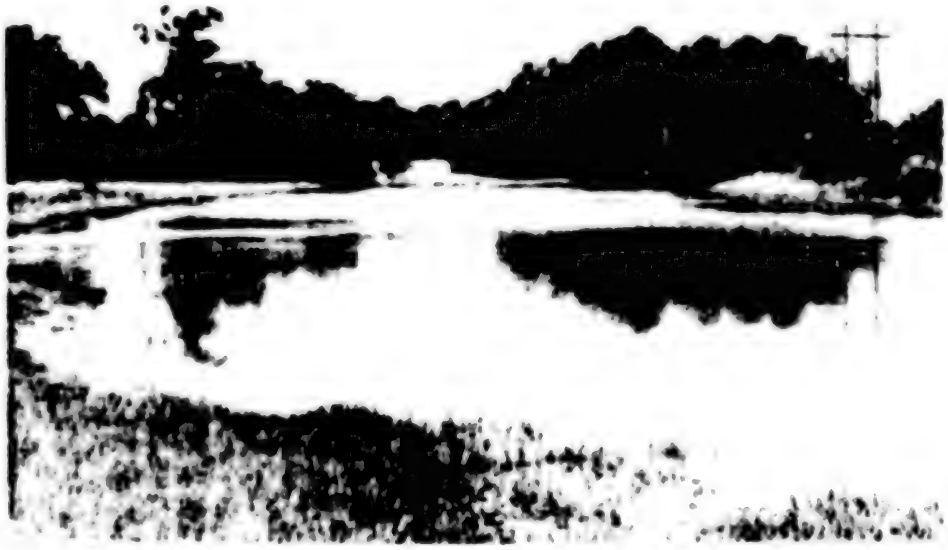


Figure 3.3-18. A seasonal pond of the type suitable for attracting wood ducks and other waterfowl (from Beshears 1974).

Seasonal feeding ponds, as implied, will serve primarily to provide food for waterfowl only during certain seasons. Additional benefits will be resting and loafing areas on the open water and on islands (Sect. 3.3.2.h) and the increased attractiveness of nearby wooded areas as wood duck nesting sites.

Planting of waterfowl food can be accomplished in different ways, depending on the management objectives of the site:

Method 1 - Objective: Basic Waterfowl Food Production

- o Japanese millet is sown on exposed mud bottoms immediately after drawdown in the spring without seedbed preparation (Figure 3.3-19).
- o Drawdown can be delayed until mid-summer for millet plantings. This decreases blackbird depredation, but often necessitates the clearing of summer weed species from the seedbed.

- In some areas, the original seeding of millet will provide enough seed, so that further seeding may not be necessary for three years. However, for best results, some seeding each year is recommended.

Method 2 - Objective: Enhanced Waterfowl Food Production

- Drain the impoundment in the early spring and use standard farming methods (fertilization, planting, cultivation, etc.) to plant crops such as corn and sorghum.

- A combination of farm grain crops and millet can be planted, where the farm grains are grown after early drawdown and Japanese millet is grown after late drawdown. Millet would be sown in the shallow parts of the impoundments, while the farm grains would be sown in the deeper areas. This combination, because of the variety of foods, is often more attractive to waterfowl than single-crop plantings.

Method 3 - Objective: Waterfowl Food Production and Fish Management

- Useful for 2-hectare (5-acre) or larger impoundments which have extensive shallow areas, good cover, and brushy edges at the upper end.

Figure 3.3-19. Sowing Japanese millet on an exposed moist mud flat immediately after drawdown (from Beshears 1974).

- The impoundment is drawn down at the upper end in mid-July and sown in Japanese millet. A late summer drawdown is generally not detrimental to fishing.

- After maturity, the standing grain is flooded in late October-early November.

## MAINTENANCE AND MANAGEMENT

Management of an impoundment for waterfowl can be accomplished by one individual doing a variety of tasks (i.e., seedbed preparation, planting, water level manipulation). These various jobs will also need to be performed at different times of the year depending on the objectives of the management (see Development above). A relaxed management or cessation of maintenance can only result in an impoundment having little or no value to waterfowl.

## LABOR/MATERIALS

Labor requirements are small, amounting to a day per year each for seeding, fertilizing (if needed), and drawdown maintenance. Recommended seed amounts are 9.1 to 11.4 kg (20 to 25 pounds) of Japanese millet per 0.4 hectare (1 acre) and standard regional planting rates for corn and sorghum. Current costs for seeds are as follows: Japanese Millet (23 kg [50 lb] bag) - $27.50; Yellow seed corn (23 kg [50 lb] bag) - $42.00; Low-growing sorghum (23 kg [50 lb] bag) - $29.25.

## SOURCES OF INFORMATION

Additional information on impoundment design suitable for waterfowl can be obtained from:

- State Regulatory Authority
- State Fish and Game Agency
- Soil Conservation Service

References cited:

Almand, J. D. Wood duck. In: How to have small game on your land ... Small game management in Georgia. Georgia Game and Fish Commission; 1971:13-20.

Anderson, W. L. Making land produce useful wildlife. USDA Farmers' Bulletin No. 2035; 1975.

Beshears, W. W., Jr. Wood ducks in Alabama. Alabama Department of Conservation and Natural Resources, Division of Game and Fish. Special Report No. 4; 1974.

Dewberry, O. The wood duck. In: Wildlife on your land - practical management for the landowner. Georgia Department of Natural Resources; no date:28-32.

Additional references:

Beshears, W. W., Jr. Wood ducks in Alabama. Special Report No. 4. Alabama Department of Conservation and Natural Resources. Division of Game and Fish. Montgomery, AL; 1974.

Bevill, V.; Mahan, W.; and Strange, T. Game on your land. Part 1 - Small game and wood duck. South Carolina Wildlife and Marine Resources Department. Columbia, SC; 1978.

Martin, A. C.; Wiler, F. M. Food of game ducks in the United States and Canada. U.S. Fish and Wildlife Service Rpt. 30; 1951.

Neely, W. W.; Davison, V. E. Wild ducks on farmland in the south. USDA Farmers' Bulletin 2218. U.S. Government Printing Office. Washington, DC; 1971.

Trippensee, R. E. Wildlife management: fur bearers, waterfowl, and fish. Volume II. New York: McGraw-Hill; 1953.

U.S. Forest Service. Wildlife habitat management handbook. U.S. Forest Service. FSH 2609.23R. Atlanta, GA; 1971.

### h. Island development for waterfowl.

PURPOSE

Small islands in permanent impoundments can provide an effective means of reducing terrestrial mammalian predation on waterfowl and their nests by providing protected nesting and loafing sites near open water (Figure 3.3-20). Many predators, such as raccoons and snakes, which may account for 50 to 90 percent of wood duck nest failure, will avoid swimming large stretches of water to gain access to a nest (Beshears 1974). The open water surrounding an island will also allow resting ducks to see foxes or feral dogs which may try to gain access to the island. Several species of migrant waterfowl which will benefit in this regard are mallards, lesser scaup, redheads, blue-winged teal, shovelers, pintails, American coot, and pied-billed grebe.

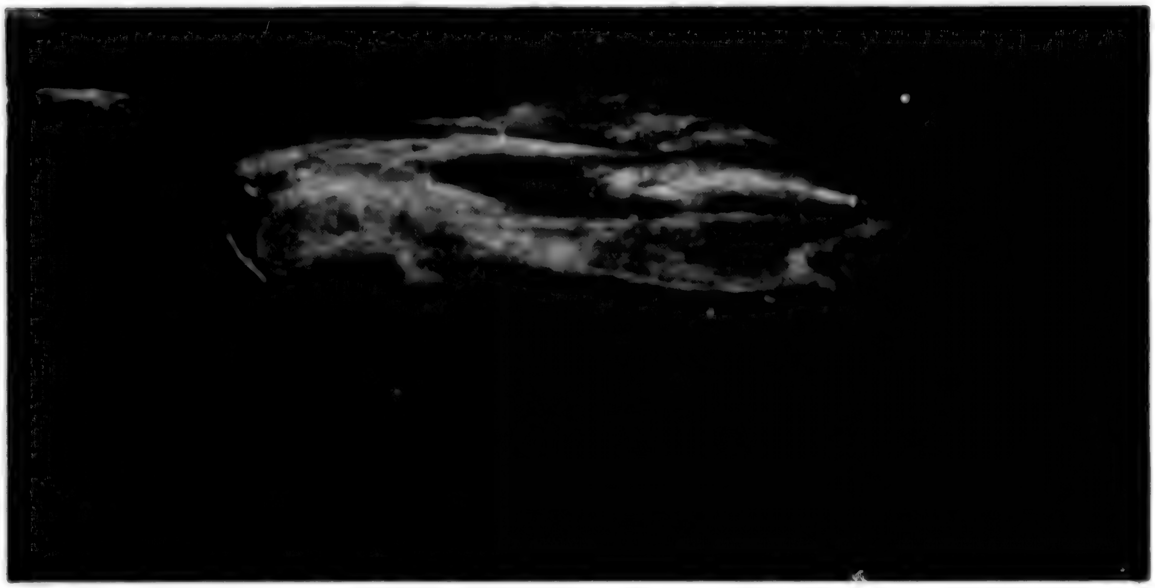


Figure 3.3-20. Aerial view of an island created for waterfowl on a surface mine reservoir (photo courtesy of North American Coal Corporation).

DEVELOPMENT

Islands can be easily and inexpensively incorporated into the construction of a permanent impoundment. The islands should be 0.02 hectare (0.05 acre) or larger, with their distance from the mainland depending on each individual situation. In Alberta, it was found that channels 0.5 to 0.6 meter (1.5 to 2 feet) deep and approximately 9.1 meters (30 feet) wide between the island and the mainland were adequate (Keith 1961). Another study recommended long, narrow islands at least 15.2 meters (50 feet) from the shore on impoundments larger than 0.81 hectares (2 acres) (McCarthy 1973). Hook (1973) found that, on large water areas, a minimum of 45.7 meters (150 feet) between islands minimizes territorial strife and encourages nesting in Canada geese. Most studies documenting the benefits of islands to waterfowl have been performed in the prairie pothole regions of the West. Because of this fact, little information is available on island size, or the recommended distances islands should be from the shore, in the eastern United States. However, considering all known information, it is recommended that islands be no closer than 9.1 meters (30 feet) to any impoundment shoreline.

During impoundment construction, potential high points or deltas within the reservoir can be built up, while land which would have been a peninsula can be separated from the mainland (Figure 3.3-21). The location of islands with respect to the prevailing wind direction can present special problems. Here, islands should be protected from strong wave action, which encourages erosion. Plantings on the mainland can reduce winds, while plantings on the island or in the shallow areas around the island can reduce wave erosion. Placement of rock or rip-rap on the exposed side of the island will also substantially reduce erosion. Islands at least 0.9 meter (3 feet) high are recommended to avoid nest destruction due to flooding and eventual settling of the ground.

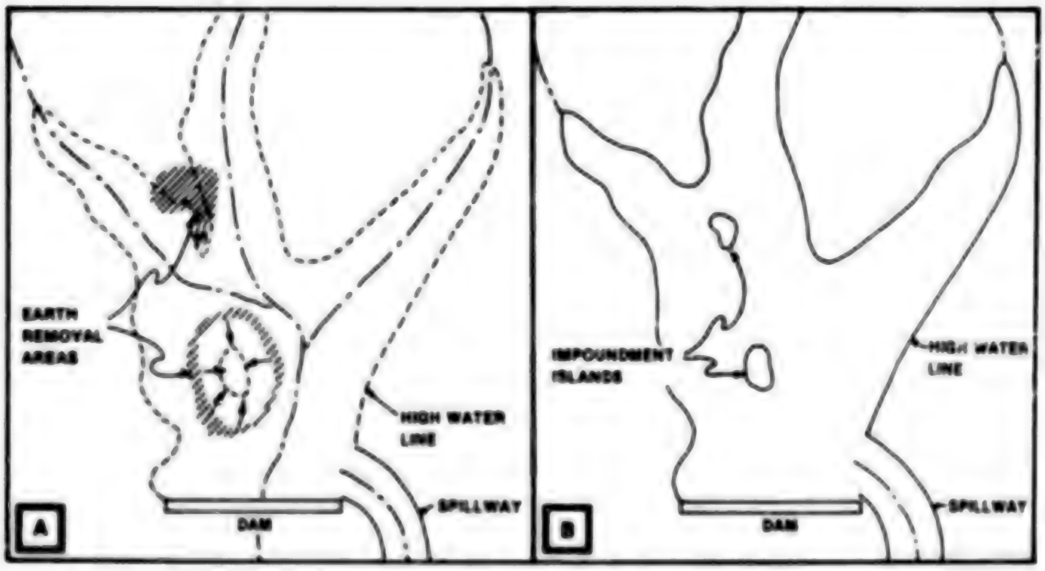


Figure 3.3-21. Schematic showing (A) possible areas of earth removal and (B) areas of placement to create post-impoundment islands (from Jones 1975).

Topsoils should comprise the upper soils on the island, and reseeding with native grass species and low-growing legumes is recommended. In general, extensive woody growth should be prevented because brushy areas that would develop are not desirable for most waterfowl. While establishing vegetation, hay should be spread on the surface of the island to encourage plant growth and to aid in stabilizing the island against wind and wave action.

To encourage wood duck nesting, some areas on an island should be planted in bushes and small trees. Once the height of this vegetation reaches 1.8 to 3.1 meters (6 to 10 feet), a nest box could be placed along the brushy edge with the opening of the box situated so that the bird can have an unobstructed access. Design specifications for a wood duck nesting box are given in Section 3.3.3.d.

## MAINTENANCE AND MANAGEMENT

If properly designed, the type of island discussed in this paper will be relatively maintenance-free. Eventually, however, woody vegetation will invade the island and begin to grow. Since plants of this type are undesirable for waterfowl habitat, they should be removed, preferably by hand-thinning, to reduce disturbance of other vegetation.

## LABOR/MATERIALS

Small islands can be created in a relatively few hours of equipment time (approximately 2 hours/island). Draglines (0.4-0.6 cu. meter [0.5-0.75 cu. yard] capacity), scrapers, and bulldozers are among the types of equipment that can be used. The actual choice of machinery is often dictated by what is being used to create the impoundment (Figure 3.3-22). An advantage of the use of heavy equipment is that compaction, resulting from operation of the machinery, will result in a more stable, erosion-resistant island.

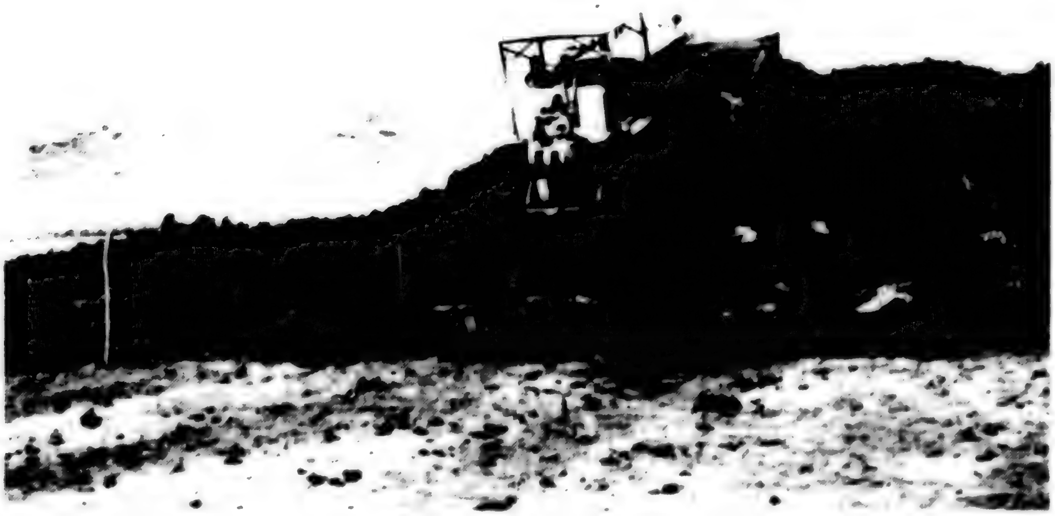


Figure 3.3-22. Earthen-mound islands can easily be constructed with a bulldozer during impoundment construction (from Jones 1975).

## SOURCES OF INFORMATION

Additional assistance and technical information can be requested from:

- State Regulatory Authority
- State Fish and Game Agency
- U.S. Fish and Wildlife Service
- Soil Conservation Service
- Office of Surface Mining
- U.S. Forest Service

References cited:

Beshears, W. W., Jr. Wood ducks in Alabama. Special Report No. 4. Alabama Department of Conservation and Natural Resources. Division of Game and Fish. Montgomery, AL. 1974.

Hook, D. L. Production and habitat use by Canada geese at Freezeout Lake, Montana. Bozeman, MT: Montana State Univ.; 1973. Thesis. 1-53.

Keith, L. B. A study of waterfowl ecology on impoundments in southeastern Alberta. Wildl. Mono. No. 6. The Wildlife Society; 1961.

Jones, J. D. Waterfowl nesting island development. Denver, CO: Technical note 260. Bureau of Land Management; 1975.

McCarthy, J. J. Response of nesting Canada geese (Branta canadensis) to islands in stockdams in northcentral Montana. Bozeman, MT: Montana State University; 1973. Thesis. 1-34.

Additional references:

Hammond, M. C.; Mann, G. E. Waterfowl nesting islands. J. Wildl. Mgmt. 20(4):345-352; 1956.

### 3.3.3 Other Habitat Improvements

#### a. Creation of topographic features for maximum habitat diversity.

PURPOSE

On the steep slopes of the Appalachian mountains, surface mining regulations are focused on recontouring of the land to the original topography. The primary intent here is to avoid leaving highwalls, which in the past had created numerous environmental problems. On the other hand, where mountaintop removal or area mining is practiced, a variance may be obtained (depending on the specific situation) for leaving a considerable amount of topographic diversity on the mine site.

In general, where topographic diversity exists, microhabitats will be created which will benefit a great variety of wildlife. Microhabitats are small or restricted sets of distinctive environmental conditions that constitute a small habitat. For example, a rock or brushpile could be thought of as a microhabitat that provides shelter and cover for rabbits and other small mammals that otherwise may not occur in the area if the piles were not there. Recontouring to leave an undulating terrain is another example because a microhabitat can be created in the lee of a small hillock. In the winter, these areas act as windbreaks, protecting wildlife from storms and exposure. These and other topographic modifications can significantly increase the variety of wildlife on an area and are recommended wherever conflicts with postmining land use do not occur.

DEVELOPMENT

The creation of topographic features to promote habitat diversity can be most successful following mountaintop removal or area mining operations. Richard Kerr (Bureau of Land Management, unpublished manuscript) has described some of the options that are available during regrading. These are presented below.

One technique is the contouring of overburden or spoil materials into a form Kerr calls a "poppy seed roll" (Figure 3.3-23). The advantages of such a form over uniform or flat areas is that it allows different sun exposures, provides various air or wind flows, and creates a variety of plant habitats. Varying sun exposures create different conditions of humidity, air, and soil temperatures. Where similar topographic shaping has been tried in the West, mule deer will congregate on the warm dry areas on south-facing slopes in winter. The windbreak effect of these land forms is also an important feature (Figure 3.3-24). Many animals can find protection on the lee sides of the slopes during storms. Deer will also congregate on the upper half of the south-facing slope in winter. To enhance the windbreak effect, vegetation can be planted to provide shelter.

Another option is contouring to create several parallel, low, rolling hills at right angles to the prevailing wind direction. This takes maximum

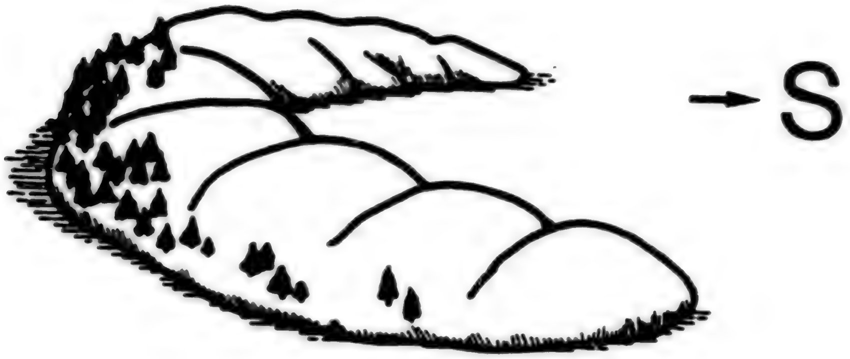


Figure 3.3-23. Contouring to create wildlife habitat.

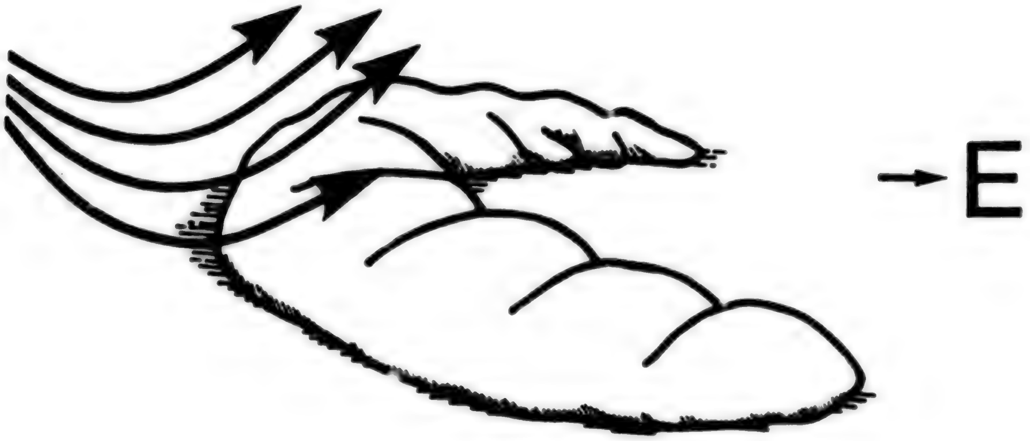


Figure 3.3-24. Windbreak effect of land contouring.

advantage of the windbreak effect that can be created during final contouring. To be effective and practical, these hills should be no more than 10 feet in height and should be spaced at intervals of 91.4 to 152.4 meters (300 to 500 feet). Breaks at intervals in the ridges and randomly placed open areas (1.2 to 2 hectares [3 to 5 acres] in size) will also make the parallel contouring more visually appealing. After being planted to grasses and legumes interspersed with small shrubs and trees, this type of area would be extremely attractive to white-tailed deer.

Allowing small pools of water to form in the low areas associated with parallel ridges and poppy seed roll forms will provide temporary water sources which are badly needed in some locations. These low areas would collect rainwater and should not be located where runoff would create erosion or acid drainage problems.

Rock- and brushpiles are features which can be used to create a more diverse habitat on a localized basis. They can be constructed following contour or area mining operations after final grading has been completed. On reclaimed areas, where protective cover is often lacking, rock- or brushpiles can be valuable assets in a wildlife enhancement program. Construction of rock- and brushpiles is discussed in Sections 3.3.3.b and 3.3.3.c.

## MAINTENANCE AND MANAGEMENT

For most of these features, mainterance would be restricted to ensuring successful growth of vegetation after the structure has been completed.

## LABOR/MATERIALS

Costs would be a function of engineering requirements and heavy equipment use. These costs would have to be balanced against the costs for reclaiming the land to its original contours.

## SOURCES OF INFORMATION

Additional information on the creation of topographic features to enhance wildlife habitat can be obtained from:

- o State Regulatory Authority
- o Office of Surface Mining
- o U.S. Fish and Wildlife Service

References cited:

Kerr, R. Ideas about reclaiming western mined lands for wildlife. Denver, CO: Unpublished manuscript, Bureau of Land Management, Denver Service Center.

### b. Brushpiles.

### PURPOSE

Brushpiles provide several benefits to wildlife such as:

- Concealment and protection from predators
- Protection from the elements
- Nesting habitat

These structures are especially beneficial in areas of limited small game habitat such as newly reclaimed areas.

### ILLUSTRATION

There are many methods of constructing brushpiles. Depending on the situation and availability of materials, construction may be accomplished in several ways. Dead and living brushpiles from residual brush materials, logs, or boulders may be utilized together or separately to provide a general habitat for small animals as shown in Figure 3.3-25 (Guti\rrez et al. 1979). When scattered throughout an area, these piles provide valuable habitat for many different types of small animals. The number and location of brushpiles can be determined by consulting with a local wildlife biologist or soil conservationist.

Construction with brush and rocks, as shown in Figure 3.3-25 (D, E, and F), provides cover with escape cavities for small mammals. Living piles can provide excellent winter cover for birds and mammals. Piles may be constructed, as shown, from rock and brush materials or exclusively from slash (Section 3.2.2.b, Use of Slash from Clearing and Grubbing).

### MAINTENANCE AND MANAGEMENT

The brushpiles provide benefits to wildlife for many years with very little maintenance requirement. In time, the brushpiles may develop into a mass of living vegetation through sprouting of the original twigs (especially in wetland areas) or from germination of seeds that are caught in the material used to construct the piles.

### LABOR/MATERIALS

Materials can generally be picked up free or stockpiled from strip mine clearing operations and hauled to the reclamation sites. An individual can construct one of these structures in 20-30 minutes.

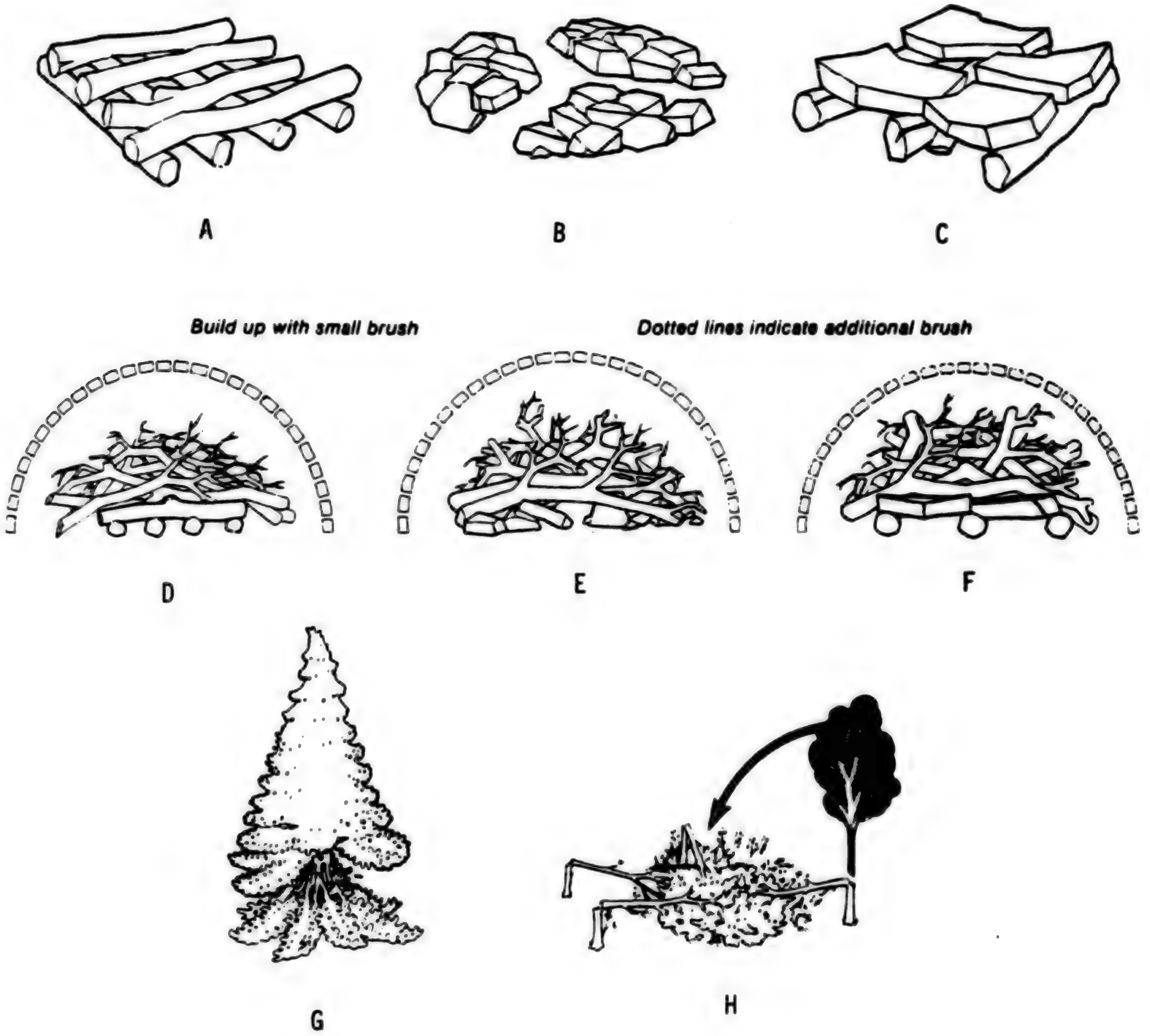

A
B
C
Build up with small brush
Dotted lines indicate additional brush
D
E
F
G
H

Figure 3.3-25. Construction of brushpile shelters demonstrating base construction methods (A-logs, B-boulders, C-log/boulder combination), dead brush construction (D-F), and living brush construction utilizing conifers (G) or hardwoods (H) (from Gutiérrez et al. 1979).

## SOURCES OF INFORMATION

More information on the use of brushpiles may be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agencies
- State Soil Conservationist
- U.S. Fish and Wildlife Service
- U.S. Forest Service

Reference cited:

Gutiérrez, R. J.; Decker, D. J.; Howard, R. A., Jr.; Lassoie; J. P. Managing small woodlands for wildlife. Extension Publication, Info. Bull. No. 157. Ithaca, NY: New York State College of Agriculture and Life Sciences at Cornell University; 1979.

Additional references:

U.S. Forest Service. Wildlife habitat improvement handbook. FSH No. 2609.11; 1969.

Warrick, C. W. Artificial brushpiles. Denver, CO: Bureau of Land Management, Tech. Note 290; 1976.

### c. Rock piles.

#### PURPOSE

Rock piles (Figure 3.3-26) provide several benefits to wildlife such as denning areas, protection from the elements, and concealment and protection from predators. They are most beneficial to the smaller game and nongame animals, especially on newly reclaimed areas where cover may not exist. Development of rock piles is also useful for enhancement of wildlife habitat in undisturbed areas adjacent to mining activities. As a mitigative measure, rock piles can be used to replace similar types of habitat structure lost during mining, such as rock outcrops. If rock piles are to be included in the reclamation plan and its implementation, they must be well planned and integrated into the overall reclamation effort. They cannot just be added as an afterthought or as an easy means for an operator to leave large quantities of rock on the surface.

#### DEVELOPMENT

Coarse, angular rocks no smaller than 15 cm (6 inches) across are ideal for constructing rock piles. Less subject to weathering and being scattered, rocks of this size provide larger interior spaces within a pile. The size of these interior spaces influences, to a large degree, the animals likely to use the structure. Rodents and cottontail rabbits will utilize small spaces, whereas woodchuck, opossum, and raccoon prefer larger spaces.

Rocks are most easily gathered when their removal from topsoil material is necessary for proper reclamation. Suitable material for building rock piles can then be stockpiled for later use or placed in piles directly on regraded areas during rock removal operations.

Rock piles should be large enough to provide an interior climate with a fairly stable temperature and humidity. A pile roughly 4.3 meters (14 feet) in diameter and 1.2 meters (4 feet) deep should be considered a minimum size for equipment-placed rock piles. This allows for some scattering of rocks around the edge. Smaller structures about 1.8 meters (6 feet) across and 0.6 to 0.9 meters (2 to 3 feet) deep may be constructed by hand.

One or two rock piles can be constructed per 0.4 hectare (1 acre) and should be placed near other habitat, such as feeding areas, water, or other cover, depending on the animals expected to utilize the structure. Rock piles placed along ridgelines can provide perches for birds of prey. Specific recommendations on rock pile sizes, placement, and number can be made by a local wildlife biologist.

#### MAINTENANCE AND MANAGEMENT

Rock piles require no maintenance. With proper placement and selection of materials, rock piles can be expected to provide benefits to wildlife indefinitely.

## LABOR/MATERIALS

Suitable material should be readily available at some stage of the mining operation. Lifting equipment, such as a front end loader or high-lift, can be used for material handling, while the placement of rocks can be performed most economically by dump truck. When rock removal is necessary for reclamation, the creation of rock piles can reduce disposal costs by reducing haulage. The loading and placement of rocks for a pile 3 meters (10 feet) in diameter by 1 meter (3 feet) high should require 1-2 man-hours of time and 1-2 hours of front end loader and dump truck time.

Figure 3.3-26. Rock piles are ideal shelters for small wildlife (from Johnson 1978).

## SOURCES OF INFORMATION

Information on the usefulness, placement, and size requirements of rock piles to benefit wildlife can be obtained from:

- State Regulatory Authority
- Office of Surface Mining
- State Fish and Game Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service

Reference cited:

Johnson, T. R. Tips on the management of amphibians and reptiles on private lands. Jefferson City, MO: Missouri Department of Conservation; 1978.

Additional reference:

Thomas, J. W., ed. Wildlife habitats in managed forests: The Blue Mountains of Oregon and Washington. U.S. Dept. of Agriculture, Forest Service, Agriculture Handbook No. 553: published in cooperation with Wildlife Management Institute and U.S. Bureau of Land Management; 1979.

### d. Nest structures.

PURPOSE

A deficiency of natural nest sites, like food, water, or any other habitat requirement, can limit wildlife success and distribution in an otherwise suitable habitat. Artificial nest structures can provide substitute nest sites in areas where former sites have been destroyed or are naturally lacking.

DEVELOPMENT

Graul (1980) presents some excellent general guidelines concerning the application of artificial nesting structures:

> The primary use of the [artificial nest] structures should be to temporarily replace lost habitat elements, i.e., the main emphasis should be upon replacing the natural habitat element. For instance, an artificial nest structure might be necessary in the interim between when a tree is lost and a new one grown.

Artificial structures might also be used for the relocation of a nesting pair of a high-value species whose natural nest site is jeopardized by a human-induced or natural perturbation.

### Nest Boxes

Nest boxes ("birdhouses") benefit a wide variety of the region's birds, including songbirds and other perching birds, woodpeckers, owls, and kestrels. They can be placed on trees, utility poles, fence posts, or abandoned buildings. These structures must meet the requirements of the target species and be properly designed, located, erected, and maintained for beneficial results (Yoakum et al. 1980). Furthermore, they must be durable, predator-proof, weathertight, lightweight, and economical to build (Yoakum 1971). Table 3.3-4 provides nest box dimensions for a variety of birds in the central and southern Appalachians. Figures 3.3-27, 3.3-28, and 3.3-29 show typical nest box construction layouts and examples of other nesting structures.

### Nest Baskets

Conical nest baskets have been constructed for ducks out of 0.6-cm (0.25-inch) hardware cloth, reinforcing rods, and a galvanized pipe support for placement in shallow water. For more information on these structures, including a complete list of materials, construction procedures, and placement considerations, see Yoakum et al. (1980).

Table 3.3.-4. Nest box dimensions and placement height for selected species of birds.

| Species | Floor |  | Depth |  | Entrance Diameter |  | Entrance Height Above Floor |  | Box Height Above Ground[a] |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | cm | (inches) | cm | (inches) | cm | (inches) | cm | (inches) | meters | (feet) |
| Eastern Bluebird | 13 x 13 | (5 x 5) | 20 - 25 | (8 - 10) | 3.8 | (1.5) | 15 - 20 | (6 - 8) | 1.5 - 3.1 | (5 - 10) |
| Carolina Chickadee | 10 x 10 | (4 x 4) | 20 - 25 | (8 - 10) | 2.8 | (1.1) | 15 - 20 | (6 - 8) | 1.8 - 4.6 | (6 - 15) |
| Yellow-shafted Flicker | 18 x 18 | (7 x 7) | 41 - 61 | (16 - 24) | 6.4 | (2.5) |  | (14 - 16) | 1.8 - 6.1 | (6 - 20) |
| Crested Flycatcher | 15 x 15 | (6 x 6) | 20 - 25 | (8 - 10) | 5.1 | (2.0) | 15 - 20 | (6 - 8) | 2.4 - 6.1 | (8 - 20) |
| American Kestrel | 20 x 20 | (8 x 8) | 31 - 38 | (12 - 15) | 7.6 | (3.0) | 22 - 31 | (9 - 12) | 3.1 - 9.1 | (10 - 30) |
| Purple Martin[b] | 15 x 15 | (6 x 6) | 15 | (6) | 6.4 | (2.5) | 3 | (1) | 4.6 - 6.1 | (15 - 20) |
| White-breasted Nuthatch | 10 x 10 | (4 x 4) | 20 - 25 | (8 - 10) | 5.7 | (2.25) | 15 - 20 | (6 - 8) | 3.7 - 6.1 | (12 - 20) |
| Barn Owl | 25 x 25-<br>46 x 46 | (10 x 10-<br>18 x 18) | 38 - 46 | (15 - 18) | 15.2 | (6.0) | 10 | (4) | 3.7 - 5.5 | (12 - 18) |
| Screech Owl | 20 x 20 | (8 x 8) | 31 - 38 | (12 - 15) | 7.6 | (3.0) | 23 - 31 | (9 - 12) | 3.1 - 9.1 | (10 - 30) |
| Yellow-bellied Sapsucker | 15 x 15 | (6 x 6) | 36 - 46 | (14 - 18) | 4.5 | (1.75) | 31 - 41 | (12 - 16) | 3.7 - 12.2 | (12 - 40) |
| Tree Swallow | 13 x 13 | (5 x 5) | 20 - 25 | (8 - 10) | 3.8 | (1.5) | 15 - 20 | (6 - 8) | 1.5 - 4.6 | (5 - 15) |
| Tufted Titmouse | 10 x 10 | (4 x 4) | 20 - 25 | (8 - 10) | 5.7 | (1.25) | 15 - 20 | (6 - 8) | 1.8 - 4.6 | (6 - 15) |
| Carolina Wren | 10 x 10 | (4 x 4) | 10 - 15 | (4 - 6) | 5.7 | (1.25) | 15 - 20 | (6 - 8) | 1.5 - 3.1 | (5 - 10) |
| House Wren | 10 x 10 | (4 x 4) | 20 - 25 | (8 - 10) | 2.8 | (1.1) | 15 - 20 | (6 - 8) | 1.5 - 3.1 | (5 - 10) |
| Downy Woodpecker | 10 x 10 | (4 x 4) | 20 - 25 | (8 - 10) | 5.7 | (1.25) | 15 - 20 | (6 - 8) | 1.8 - 6.1 | (6 - 20) |
| Red-bellied Woodpecker | 15 x 15 | (6 x 6) | 31 - 36 | (12 - 14) | 6.4 | (2.5) | 25 - 31 | (10 - 12) | 3.7 - 6.1 | (12 - 20) |
| Red-headed Woodpecker | 15 x 15 | (6 x 6) | 31 - 38 | (12 - 15) | 5.1 | (2.0) | 23 - 31 | (9 - 12) | 3.7 - 6.1 | (12 - 20) |
| Wood Duck |  |  |  |  |  |  |  |  |  |  |
| (wooden box) | 31 x 31 | (12 x 12) | 61 | (24) | 7.6 x 10.2 | (3 x 4) | 46 | (18) | 2.4 - 4.6[c] | (8 - 15)[c] |
| (metal cylinder) | 31 dia. | (12 dia.) | 61 | (24) | 10.2 | (4.0) | 46 | (18) | 2.4 - 4.6[c] | (8 - 15)[c] |

[a] Data indicate that boxes at moderate heights, mostly within reach of a man on the ground, are readily accepted by many birds.

[b] Dimensions for one compartment.

[c] 1.5 meters (5 feet) when placed on pole or tree in water.

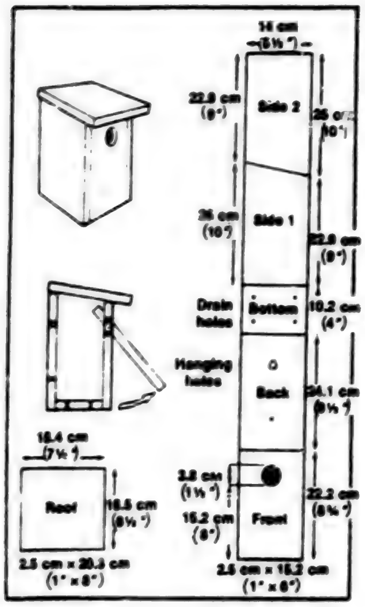


Figure 3.3-27. Eastern bluebird box (from Gutiérrez et al. 1979).

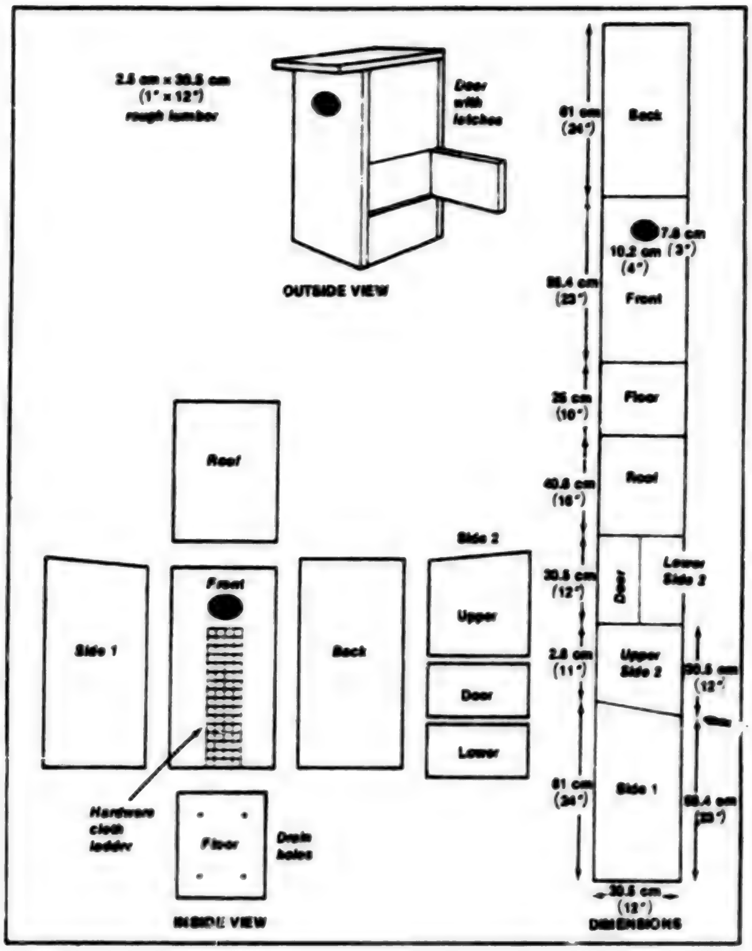


Figure 3.3-28. Wood duck nest box (from Gutiérrez et al. 1979).

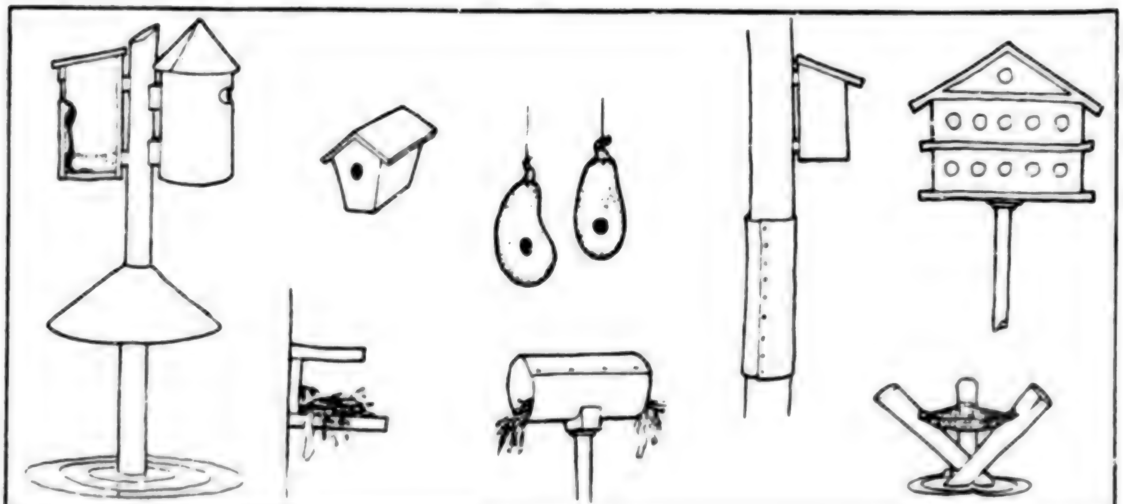


Figure 3.3-29. Examples of bird nest structures (from Gutiérrez et al. 1979).

### Nest Cones

Because of the likelihood for the loosely constructed twig nests of mourning doves to be destroyed during storms, artificial nest cones can be used to improve nesting survival (Ohio Department of Natural Resources no date). The cones are easily constructed out of a 31-cm (12-inch) square of 0.6- or 1.0-cm (0.25- or 0.38-inch) hardware cloth and can be installed with nails or staples in the forks of tree branches. Recommended sites must command good visibility, provide adequate clearance for the birds to easily escape danger, and occur in modest shade, 1.8-4.9 meters (6-16 feet) above the ground.

### Nest Cover

Normal revegetation procedures during reclamation produce suitable nesting cover for a variety of grassland nesting birds and other wildlife. Shomon et al. (1966) provide suggestions for maintaining and enhancing nest cover for wildlife.

1. Maintain permanent, undisturbed cover along fences, roads, odd corners, and wherever possible.
2. Fence nesting cover where possible to prevent grazing by livestock.
3. Plant shrubby thickets for use as cover in areas unused for other purposes.
4. Refrain from dryland fallowing operations during the nesting season to enable ground nesting birds to raise their brood in these important stubble habitats.
5. Use flushing devices on mowers to save nesting females during the first cutting of the crop.

## MAINTENANCE AND MANAGEMENT

Nest structures should be checked before each breeding season and repaired if necessary. Nest cones for mourning doves should be cleaned out after each nesting season. Generally, nest boxes do not need to be cleaned out yearly.

## LABOR/MATERIALS

Nest boxes and other nesting structures can be constructed using mass production techniques to reduce labor costs. Correctly placing nest structures requires more time than manufacturing them. As an example, bluebird boxes average approximately $5.00 for materials and one man-hour per box to build.

Rough-sawn hardwood lumber, especially white oak, will produce long-lived structures. Mill-run lumber can be purchased inexpensively from a local sawmill. If pine is used, it should be treated with a preservative. A nest box for bluebirds requires about 4,720 cc (2 board-feet) of lumber, while a wood duck nest box requires about 23,600 cc (10 board-feet).

## SOURCES OF INFORMATION

Additional information on nesting structures can be obtained from:

- State Regulatory Authority
- State Fish and Game Agencies
- Office of Surface Mining
- U.S. Fish and Wildlife Service
- U.S. Forest Service

References cited:

Graul, W. D. Grassland management practices and bird communities. Proceedings of management of western forests and grasslands for nongame birds. U.S. Forest Service Tech. Rep. INT-86. Intermountain Forest and Range Exp. Sta., Ogden, UT, 84401; 1980:38-47.

Gutierrez, R. J.; Decker, D. J; Howard, R. A., Jr.; Lassoie, J. P. Managing small woodlands for wildlife. Extension Services Info. Bull. 157. Ithaca, New York: New York State College of Agriculture and Life Sciences at Cornell University; 1979.

Ohio Department of Natural Resources. Attracting birds in Ohio. Division of Wildlife; no date.

Shomon, V. V.; Ashbaugh, B. L.; Tolmon, C. D. Wildlife habitat improvement. New York: Natl. Audubon Soc.; 1966.

Yoakum, J. Habitat improvement. In: Teague, R. D., ed. A manual of wildlife conservation. Washington, DC: The Wildlife Society; 1971.

Yoakum, J.; Dasmann, W. P.; Sanderson, H. R.; Nixon, C. M.; Crawford, H. S. Habitat improvement techniques. In: Schemnitz, S. D., ed. Wildlife management techniques manual. Washington, DC: The Wildlife Society; 1980.

# 4. REGIONAL RECLAMATION PLANNING

## 4.1 INTRODUCTION

The coal mining area in the Central and Southern Appalachian Region includes parts of southern West Virginia, southwestern Virginia, eastern Kentucky, east and middle Tennessee, northwestern Georgia, and northern Alabama. The coal in this area lies embedded in the rock strata of the Appalachian Plateaus Physiographic Province. This includes the Cumberland Plateau, Cumberland Mountains, and parts of the unglaciated Allegheny Plateau. The physiographic character of this region greatly affects the type of mining and reclamation technology which can be successfully utilized. The land varies from flat to rolling plateau in parts of Tennessee, to highly dissected tableland with steep slopes in Alabama, Tennessee, Kentucky, and West Virginia, to mountain slopes in East Kentucky, Virginia, and West Virginia. Acid overburden is a common problem influencing stream quality as well as revegetation success. For the most part, mining affects wildlife habitat in the form of temporary removal of second growth mixed oak or oak-pine forests and aquatic habitat in the form of toxic drainage and sedimentation of streams.

The forests in the coal regions are typically second growth remnants of the original forests. In general, the area is characterized by mixed oak, oak-hickory, and pine-oak communities. Depending on the location in the Central/Southern Appalachian coal region, the predominant vegetation changes. In the southern end of the region, pine-oak and mixed oak forests are common. The relative percentage of pine increases in the southern part of the region in Alabama and Georgia. Virginia pine and shortleaf pine are associated with white oak, chestnut oak, scarlet oak, southern red oak, post oak, northern red oak, pignut hickory, mockernut hickory, black gum, sourwood, and dogwood. The species mix in the forest canopy depends on local factors of slope position, aspect, soils, and forest history.

The relative importance of pine decreases northward in Tennessee. The forests on the uplands may generally be thought of as mixed oak. The forest is composed of a matrix of mixed oak-dominated communities. In poorly drained sites, red maple stands occur, while on ridges with shallow soils, Virginia pine dominates. The forests of the slopes vary from chestnut oak stands on upper slopes to mixed mesophytic on lower slopes (Hinkle 1978). The mixed mesophytic is prominent northward in Kentucky, Virginia, and West Virginia (Braun 1950). Species such as beech, sweet birch, yellow birch, buckeye, basswood, sugar maple, northern red oak, and white oak add to the canopy in the mixed mesophytic forests.

The oak and pine-oak forests serve as habitat to many game and nongame species. White-tailed deer, wild turkey, ruffed grouse, gray squirrel, bobcat, opossum, raccoon, fox, wild pigs, bear, and many other species depend on these forests for food and cover. Many nongame woodland birds depend on these forests for nesting, food, and cover.

## 4.2 EXAMPLE RECLAMATION PLAN

The Frost Bottom Mine is presented in the following pages as an example of the reclamation of a hypothetical site in the Central and Southern Appalachian Region. The site is typical of areas in which contour mining would be used. The slope is relatively steep, ranging from 35 to 54 percent in an area of mountainous topography (Figure 4.2-1).

The current land use of the area is essentially fish and wildlife habitat and is continuously forested with oak-hickory and pine-oak (Figure 4.2-2). The forests are typical of second growth woodlands which are logged regularly on a 25-30 year rotation. The oak forest occurs on the northerly aspects and the pine-oak occurs on the drier more southerly aspects of the site. The forests are typical of mid-slope forests in the region. The predominant species in the oak-hickory forest include white oak, chestnut oak, black oak, northern red oak, pignut hickory, and mockernut hickory, with some tulip poplar. The predominant species in the drier pine-oak include Virginia pine, shortleaf pine, white oak, scarlet oak, post oak, and southern red oak.

The soils on these mountainous slopes are derived from sandstone and shale colluvial materials. They are generally well drained and are loamy, mixed and siliceous Dystrochrepts and loamy, mixed and siliceous Hapludults. In the area of the Frost Bottom site, the Muskingum-Gilpin-Jefferson Association (steep, well drained, loamy soils from sandstone and shale) is prominent. The deep, loamy Jefferson soil is common on the talus slopes while, in some coves, areas of the stony Grimsley soil occurs (Figure 4.2-3).

The postmining land use on the Frost Bottom site will be fish and wildlife habitat. Emphasis will be placed on attracting deer and providing brooding area for ruffed grouse. Some flat areas, including a narrow bench, will be maintained by bush hogging to provide open hunting areas within the forest. The rest of the area will be left to natural succession after bond release.

Revegetation will be designed to take into consideration the two major aspects of the site (i.e., north facing slopes with oak-hickory and south facing slopes with pine-oak). The reclamation scheme incorporates wildlife cover, food, and water sources. A combination of herbaceous species and shrubs will be planted in patches throughout the area to provide habitat diversity and edge. Based on the premine vegetation cover and site characteristics, selected tree species will be planted to enhance the return to natural forest cover.

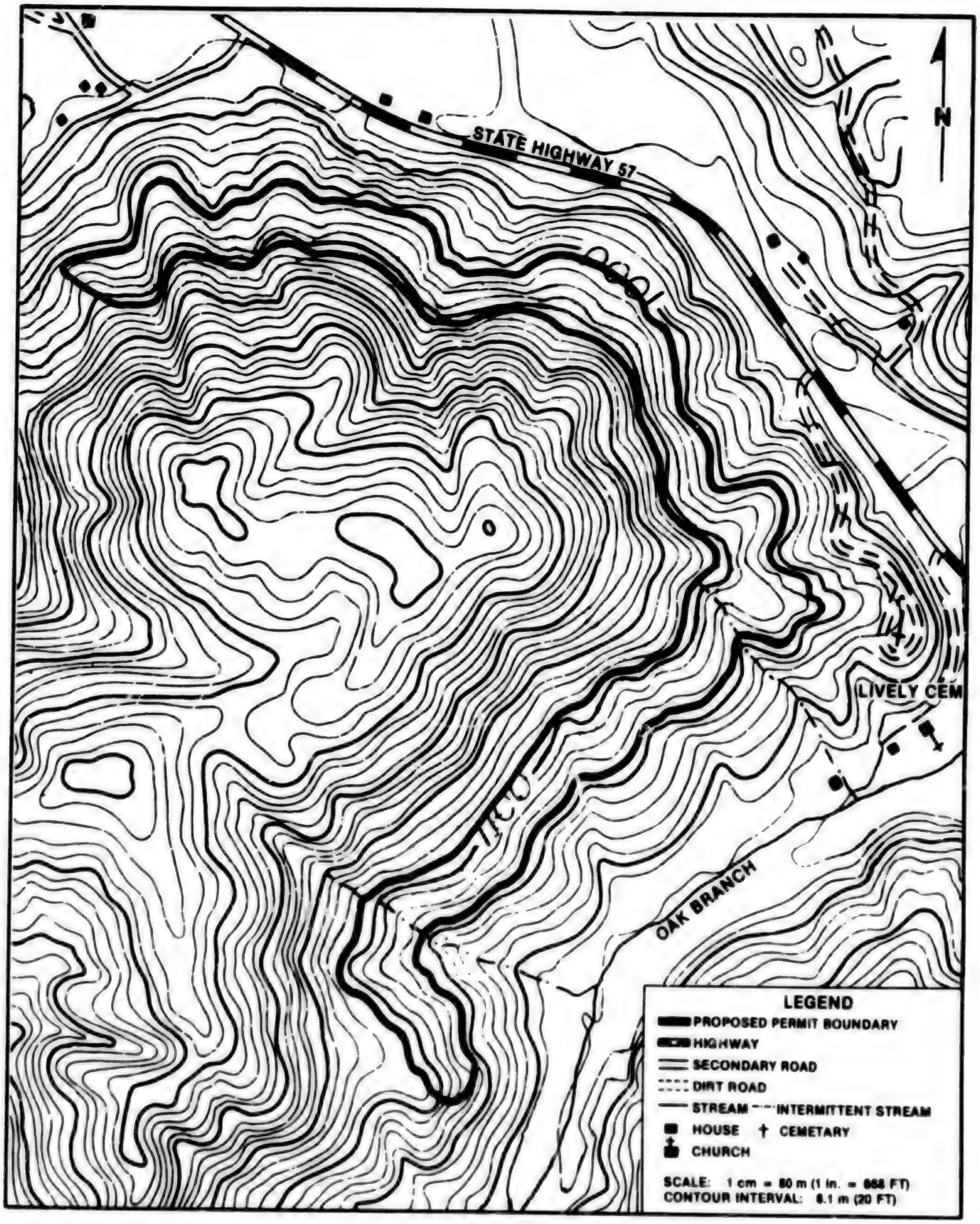


Figure 4.2-1. Topographic map showing the contour of the Frost Bottom Mine site area.

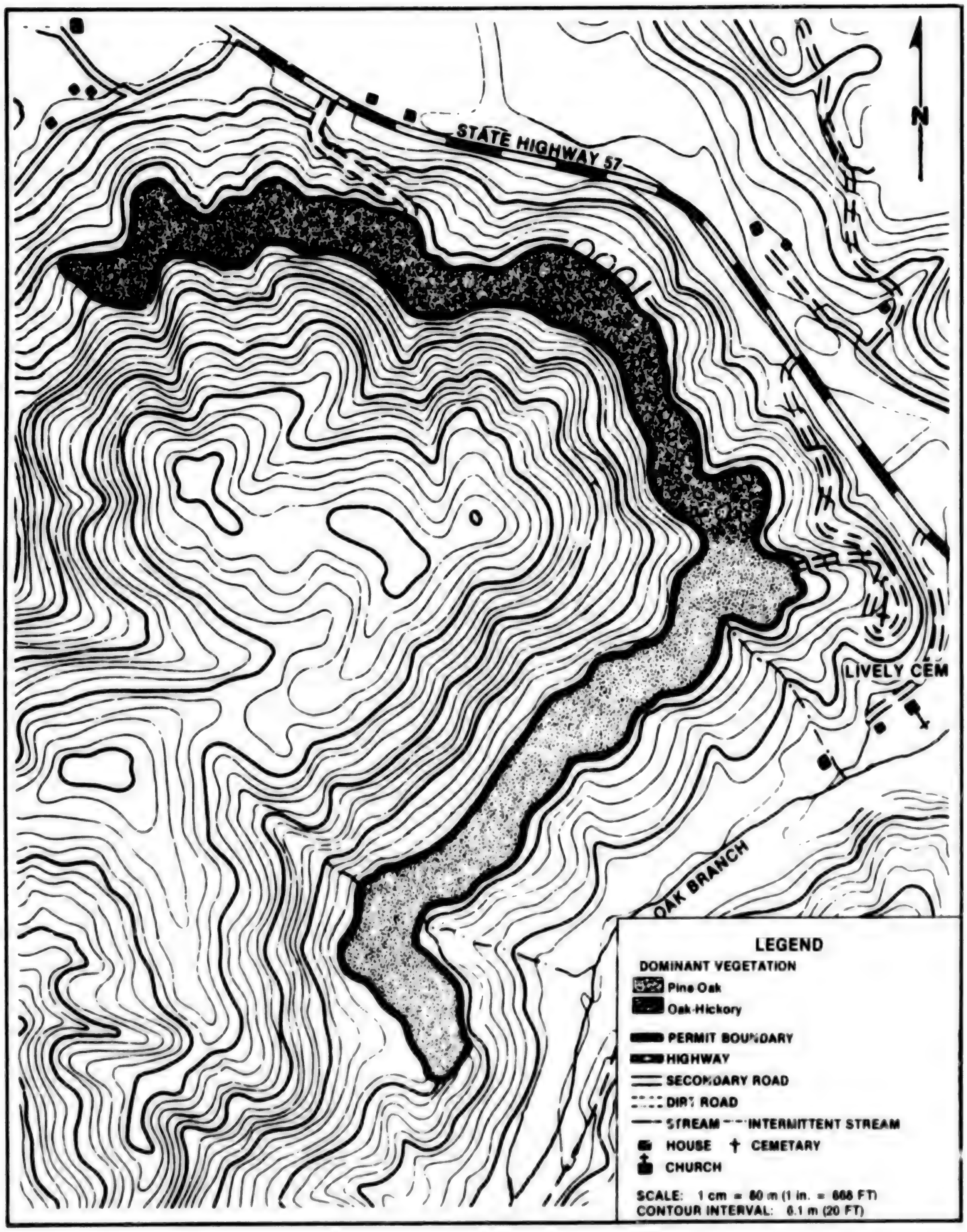


Figure 4.2-2. Vegetation types on the Frost Bottom Mine site.

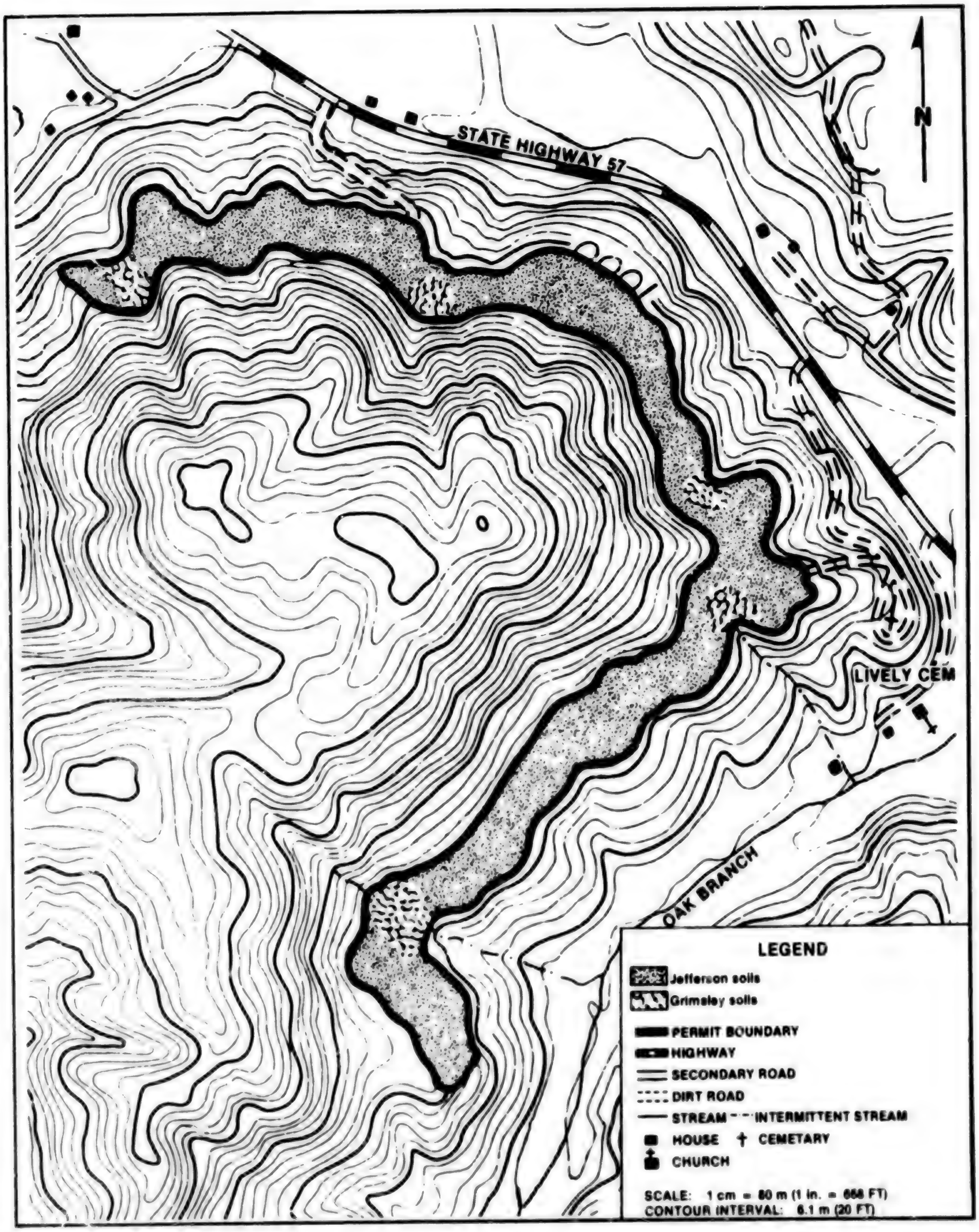


Figure 4.2-3. Soils on the Frost Bottom Mine site.

### 4.2.1 Site Preparation

a. Grading and shaping. On the contour operation, the mined area will be backfilled to approximately the original contour as shown in Figure 4.2-4. The backfilling will be done in 1.2-m (4-ft) lifts to insure the necessary stability and compaction, and the grading will be done to allow for natural drainage patterns. A diversion ditch, located 4.6 m (15 ft) back from the top of the highwall, will divert runoff into safe drainageways. This diversion ditch will be approximately 0.6 m (2 ft) wide, 0.6 m (2 ft) deep, and filled with loose rock. Other diversion ditches will be located at intervals on the backfilled ground slope. On some locations, terraces (from 20 to 290 feet in width) would be created to provide locations for permanent food plots and for protection from deposition into the permanent impoundment (see discussion under Sect. 4.2.3.a for retention of the pond). A bench will be left around the outslope of the mine for the purpose of providing access for a tractor and bush-hog to maintain the food plots. Figures 4.2-5 and 4.2-6 illustrate the proposed regrading scheme for terraced and nonterraced areas of the site. Dozers and graders will perform the grading and shaping for this operation.

In the drainage above the permanent impoundment, crushed stone will be used to line the intermittent waterway leading into the impoundment. This will reduce water velocity, and subsequent runoff of soils and organic material from the regraded area. Crushed stone will also be placed in diversion ditches where the slope is steep, with the drainageways ending downslope in the undisturbed natural watercourse.

### Soil Amendments

Although segregated topsoil will be used to cover the recontoured spoil, lime will be added to bring the spoil to a pH range of 5.5 or higher. This is to reduce the potential toxicity of aluminum and manganese present in area soils (indicated in the permit tests from the State Soil Testing Laboratory). Hydrated lime will be applied with a hydroseeder and disced into place. The lime will be mixed with the topsoil material to a depth of at least 15 cm (6 in) at a rate of 8,971 kg/hectare (4 tons/acre).

The following rates of fertilizer application will be used: nitrogen (56 kg/hectare [50 lbs/acre]), phosphorous (112 kg/hectare [100 lbs/acre]). The application will consist of a mix of 100 kg (220 lbs) of diammonium phosphate fertilizer (18-46-0) plus 27 kg (60 lbs) of ammonium nitrate fertilizer (33.5-0-0). This mix will constitute a bulk fertilizer application rate of 127 kg (280 lbs) per acre. Application will be by hydroseeder, spread with the seed mixture soon after grading and liming. A second application of fertilizer will be in the fall since seeding and first application are in the spring.

### Mulching

Due to the steep slopes, shredded bark will be mixed with straw to help keep the straw in place. The mixture will be applied with an Estes Spreader at a rate of 3,364 kg of straw and 18.6 cubic meters of bark per hectare (1.5 tons of straw and 60 cubic yards of bark per acre) (Rafaill and Vogel 1978).

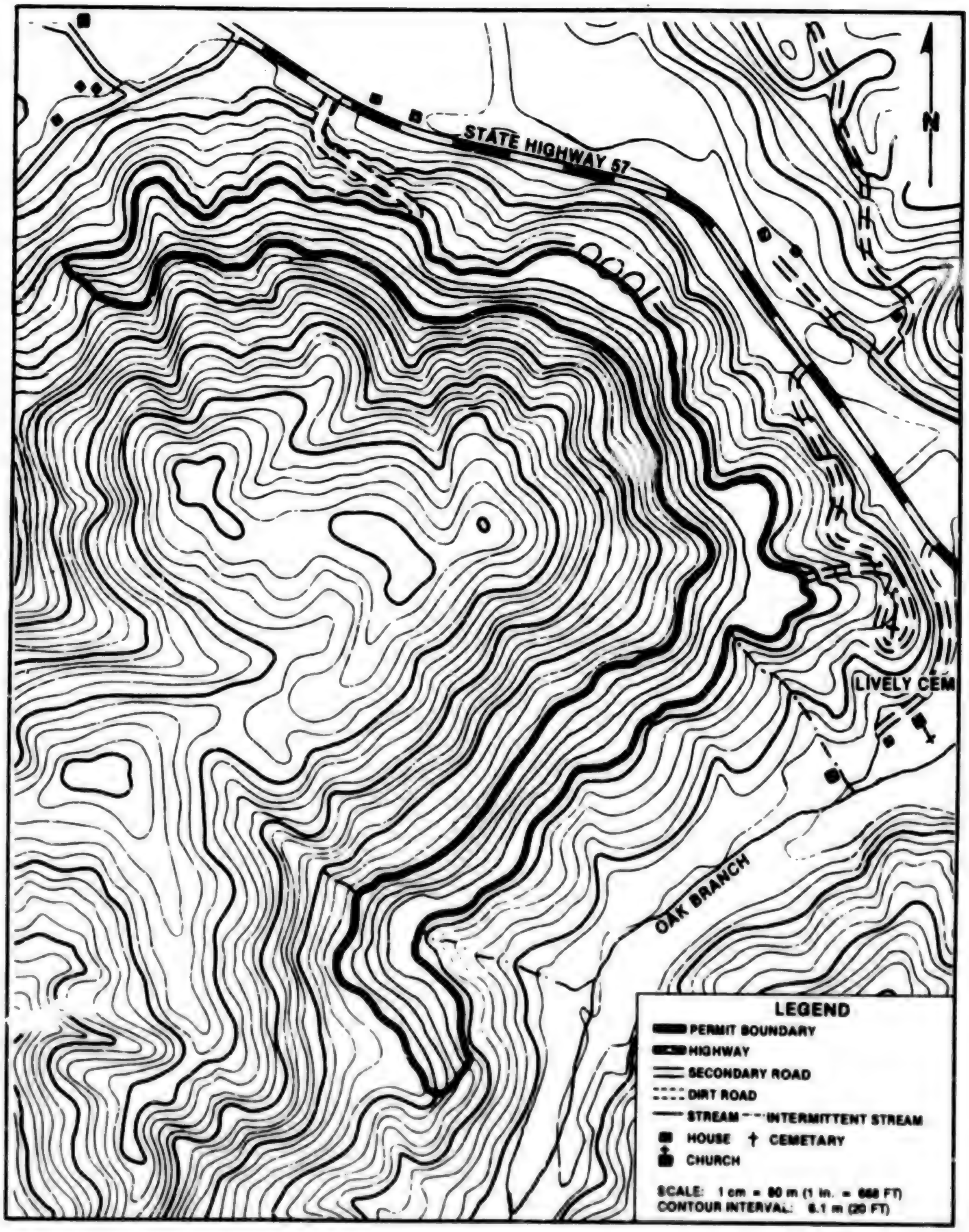


Figure 4.2-4. Recontoured topography of the Frost Bottom Mine site and adjacent areas.

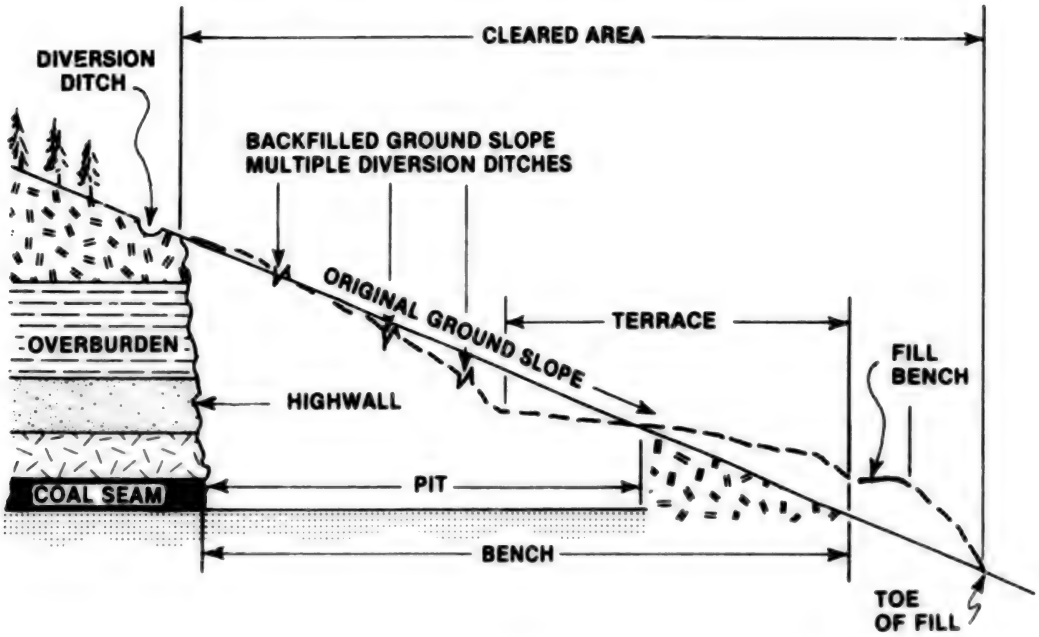


Figure 4.2-5. Recontouring scheme for the terraced areas of the Frost Bottom Mine.

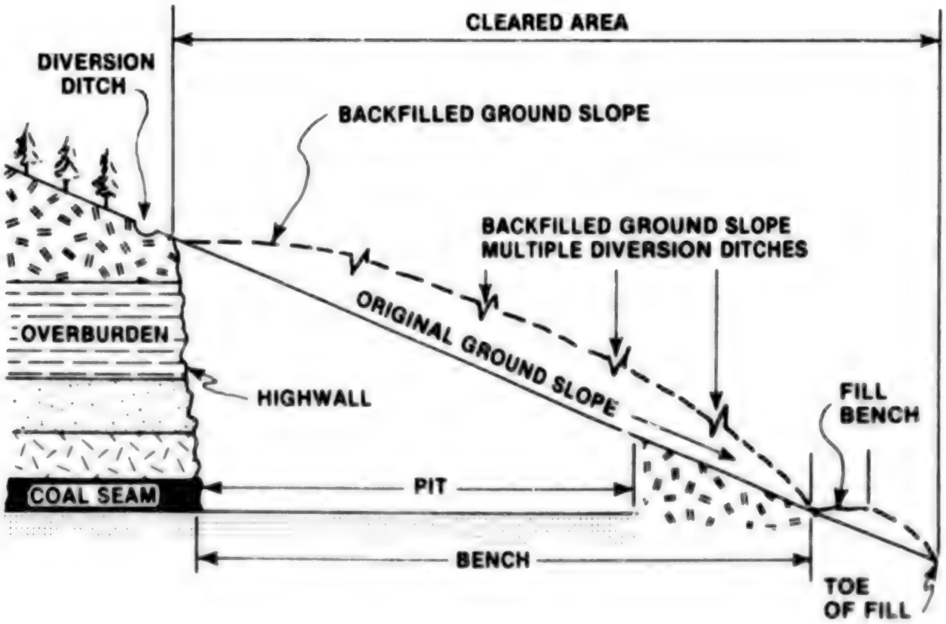


Figure 4.2-6. Recontouring scheme for the nonterraced areas of the Frost Bottom Mine.

### 4.2.2 Reclamation Plantings

a. Revegetation. The reclamation plan for the Frost Bottom Mine includes the revegetation scheme shown in Figure 4.2-7. Table 4.2-1 summarizes the proposed planting rates.

Area 1 will be hydroseeded with the herbaceous mixture shown in Table 4.2-1. This mixture not only stabilizes the site but also provides wildlife food and cover. Autumn olive and sumac will be alternated in 30.5 m (100 ft) single hand planted rows on the downslope side of Area 1. This will provide an edge between the reclaimed site and the forest downslope.

Area 2 will be hydroseeded with a different herbaceous mixture than Area 1 to provide variety in the wildlife plantings. Double rows of autumn olive and toringo crabapple will be hand planted (2.1 m by 2.4 m [7 ft by 8 ft]) on three downslope sides of Area 2.

Areas 3 and 4 will be hydroseeded as shown in Table 4.2-1. After two years, they will be planted in trees. Tulip poplar and northern red oak will be planted on northerly slopes (Area 3) and Virginia pine and shortleaf pine will be planted on southerly slopes (Area 4). Rows will be 2.1 m by 2.4 m (7 ft by 8 ft), alternating 1 to 5 rows of one species and 1 to 5 rows of the other. Tree species are chosen based on success in such sites, and the species are amenable to the reestablishment of the native forest.

Area 5 will be stabilized by a mixture (Table 4.2-1) that also provides good wildlife food and cover. Autumn olive will be planted between the reclaimed area and forest in a single row along the upslope edge.

A band 61 m (200 ft) wide will be seeded around the permanent impoundment. The mixture includes: Japanese millet (11.2 kg/ha; 10 lb/ac); Redtop (2.2 kg/ha; 2 lb/ac); and Ky-31 tall fescue (11.2 kg/ha; 10 lb/ac). This stabilizes the slope around the pond as well as provides wildlife food.

Planting of herbaceous seed mixtures will occur in March. Autumn olive, toringo crabapple, and sumac will be hand planted at the same time as the herbaceous mixtures. The tree species (Areas 3 and 4) will be planted in the established herbaceous cover during the fall of the second year.

b. Maintenance. The terraced areas (plots labeled 2, Figure 4.2-7) will be periodically cut with a tractor and brush mower to maintain grass and legumes in these locations as food plots. The primary purpose of mowing will be to keep new growth of brush and saplings from shading out the growth of the food plants. Additional maintenance or replanting of the reclaimed areas is deemed unnecessary for the proposed postmining land use designation. The rest of the area will be allowed to revert to native forest.

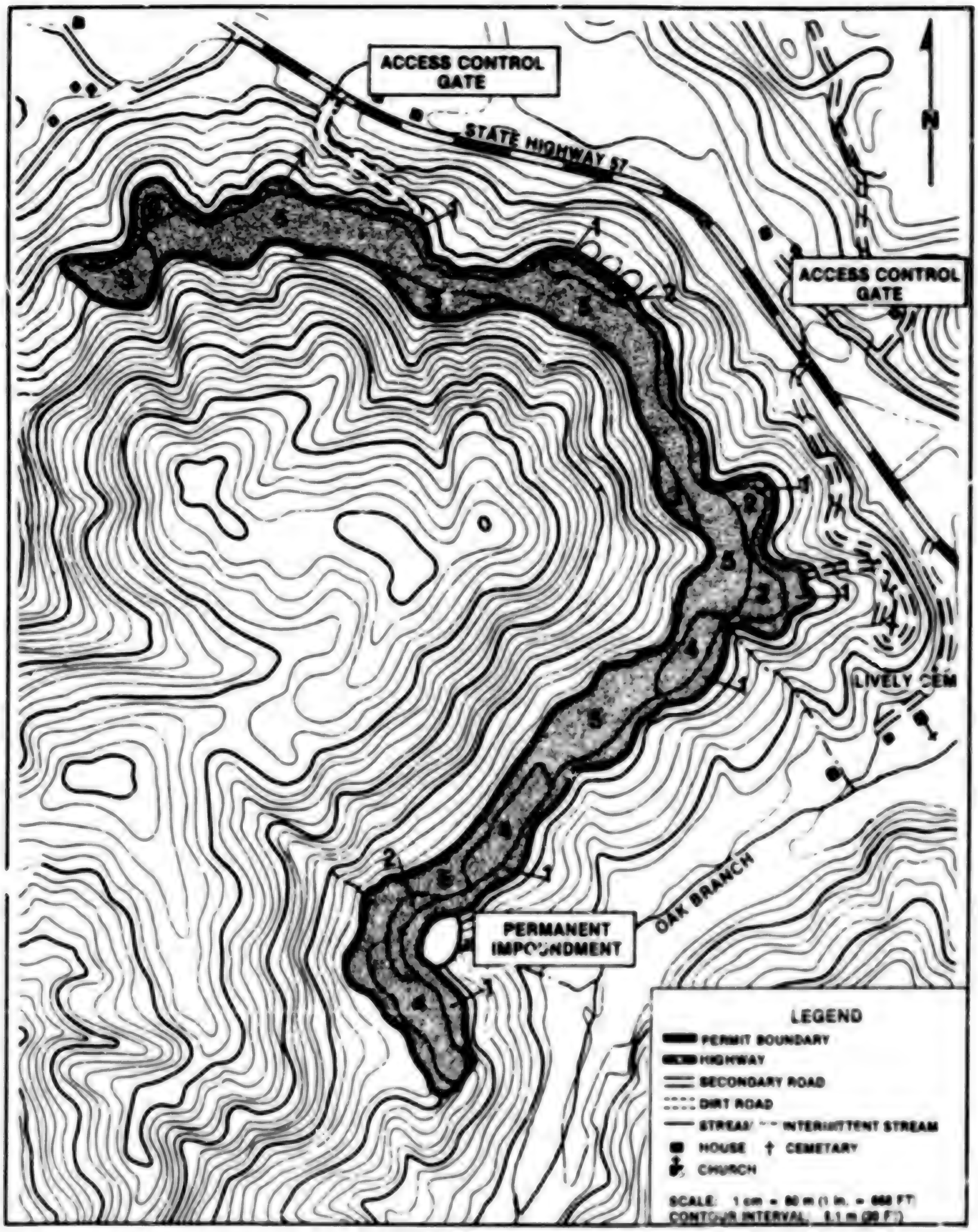


Figure 4.2-7. Revegetation scheme for the Frost Bottom Mine site.

Table 4.2-1. Plantings Proposed for the Frost Bottom Mine Site

| Area | Size | Planting[a] | Rate[b] |
|---|---|---|---|
| 1 | 1.5 ha (3.6 ac) | Herbaceous: | |
| | | Tall fescue (Ky 31) | 28.1 kg/ha (25 lbs/ac) |
| | | Orchard grass | 11.2 kg/ha (10 lbs/ac) |
| | | Birdsfoot trefoil | 9.0 kg/ha (8 lbs/ac) |
| | | Trees/Shrubs: | |
| | | Autumn Olive | 1977 per ha (800 per ac) |
| | | Sumac | 1977 per ha (800 per ac) |
| 2 | 1.0 ha (2.5 ac) | Herbaceous: | |
| | | Timothy | 9.0 kg/ha (8 lbs/ac) |
| | | White clover | 1.1 kg/ha (1 lb/ac) |
| | | Red clover | 4.5 kg/ha (4 lb/ac) |
| | | Korean lespedeza | 11.2 kg/ha (10 lb/ac) |
| | | Trees/shrubs: | |
| | | Autumn olive | 1977 per ha (800 per ac) |
| | | Toringo crabapple | 1977 per ha (800 per ac) |
| 3 | 1.4 ha (3.5 ac) | Herbaceous: | |
| | | Tall fescue (Ky 31) | 16.8 kg/ha (15 lbs/ac) |
| | | Birdsfoot trefoil | 9.0 kg/ha (8 lbs/ac) |
| | | Trees/shrubs: | |
| | | Tulip poplar | 1977 per ha (800 per ac) |
| | | Northern red oak | 1977 per ha (800 per ac) |
| 4 | 2.1 ha (5.2 ac) | Herbaceous: | |
| | | Tall fescue (Ky 31) | 16.8 kg/ha (16 lbs/ac) |
| | | Birdsfoot trefoil | 9.0 kg/ha (8 lbs/ac) |
| | | Trees/shrubs: | |
| | | Virginia pine | 1977 per ha (800 per ac) |
| | | Shortleaf pine | 1977 per ha (800 per ac) |
| 5 | 7.7 ha (19.1 ac) | Herbaceous: | |
| | | Orchardgrass | 11.2 kg/ha (10 lbs/ac) |
| | | White clover | 2.2 kg/ha (2 lbs/ac) |
| | | Red clover | 6.7 kg/ha (6 lbs/ac) |
| | | Trees/shrubs: | |
| | | Autumn olive | 1977 per ha (800 per ac) |

[a] Species mixes were adapted from Rafaill and Vogel (1978).

[b] Rates were adapted from Rafaill and Vogel (1978). For herbaceous species rates are for Pure Live Seed (PLS). Bulk seeding rate is calculated as:

$$\text{Bulk rate} = 100 \times \frac{\text{Recommended Pounds PLS per acre}}{\text{Percent PLS in Commercial Seed}}$$

and

PLS = Percent germination x Percent purity.

### 4.2.3 Additional Enhancement for Wildlife

a. Sediment pond retention. It is proposed that the sediment pond located on Figure 4.2-7 be retained as a permanent impoundment for wildlife. During the final grading of the area surrounding the pond, the sediment will be cleaned out and transported to an off-site disposal location. Then, immediately after grading, the slopes and banks will be planted with the grass-legume mixture used in Area 1 on Figure 4.2-7 and mulched. Periodic checks of the impoundment every three months will be made to determine its structural integrity. It is expected that, by the end of the bonding period, the pond will begin to show signs of following the natural ecological successional pattern of woodland ponds by filling with organic debris and supporting many aquatic and semiaquatic plants. Eventually, the debris accumulation and plant growth is expected to transform the open pond area into marsh and then dry woodland. The entire successional sequence may take 50+ years to go from open pond to dry woodland, during which time the pond area will support a variety of different plants and animals.

b. Brushpiles. Brush which had been stockpiled during the clearing operation for the mine will be trucked to regraded areas and placed in piles approximately 1.5 m (5 ft) high and 3.1 m (10 ft) in diameter. No more than 3 piles per hectare (one pile per acre) will be created. The piles will contain a variety of woody material varying from logs not more than 20 cm (8 in) in diameter to small saplings and debris cuttings. It is expected that these piles will provide cover for small wildlife, both game and nongame species (Gutierrez et al. 1979).

c. Nest boxes. Ten bluebird boxes will be erected on the area, placed no closer than 30.5 m (100 ft) apart to reduce bluebird territorial competition. The dimensions of the boxes will also be specifically designed for bluebirds to keep other more aggressive and undesirable birds (i.e., starlings) from occupying the box. Boxes will be checked periodically to determine if repairs are needed.

d. Access restriction. Access to the reclamation site will be prohibited to encourage reclamation regrowth and wildlife protection. Locked gates will be erected at access points off the main roads as shown on Figure 4.2-7, and signs posted.

### SOURCES OF INFORMATION

References cited:

Braun, E. L. Deciduous forests of eastern North America. New York: Macmillan Publ. Co., Inc.; 1950.

Gutiérrez, R. J.; Decker, D. J.; Howard, R. A., Jr.; Lassoie, J. P. Managing small woodlands for wildlife. Extension Services Info. Bull 157. Ithaca, New York: New York State College of Agriculture and Life Sciences at Cornell University; 1979.

Hinkle, C. R. The relationship of forest communities and selected species to edaphic and topographic factors on the Cumberland Plateau of Tennessee. Knoxville, TN: The University of Tennessee, Ph.D. Thesis; December 1978.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; July 1978.

# APPENDIX A

# CONSULTATION AND COORDINATION DIRECTORY

## ALABAMA

### State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Surface Mining Reclamation Commission<br>P.O. Box 2390<br>Jasper, Alabama 35501<br>(205) 221-4130 |
| Fish and Wildlife | Division of Game and Fish<br>Department of Conservation and Natural Resources<br>64 N. Union Street<br>Montgomery, AL 36130<br>(205) 832-6300 |
| Heritage and Conservation Program | TVA Regional Natural Heritage Project<br>Office of Natural Resources<br>Forestry Building<br>Norris, TN 37828<br>(615) 494-9800 |
| Forestry | Forestry Commission<br>513 Madison Avenue<br>Montgomery, AL 36130<br>(205) 832-6587 |
| Extension Services (Natural Resources, Wildlife, Fisheries, Forestry) | State Extension Services<br>Auburn University<br>Auburn, AL 36830<br>(205) 826-4444 |
| Water Resources Technology | Water Resources Research Institute<br>202 Hargis Hall<br>Auburn University, AL 36849<br>(205) 826-5075 |
| Road Construction and Maintenance | Highway Department<br>11 South Union St.<br>Montgomery, AL 36130<br>(205) 832-5637 |

## Federal Agencies

Department of Agriculture

U.S. Forest Service
Southern Region
Suite 800
1720 Peachtree Road, N.W.
Atlanta, GA 30307
(404) 881-4191

Soil Conservation Service
Wright Building
138 South Gay Street
P.O. Box 311
Auburn, AL 36830
(205) 821-8070

Department of the Army

U.S. Army Corps of Engineers
Nashville District
P.O. Box 1070
Nashville, TN 37202
(615) 251-5626

U.S. Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile, AL 36628
(205) 690-2511

Department of the Interior

Office of Surface Mining, Reclamation,
and Enforcement, Region II
530 Gay Street, S.W.
Suite 500
Knoxville, TN 37902
(615) 971-5100

Bureau of Land Management
Eastern States Office
350 S. Pickett Street
Alexandria, VA 22304
(703) 235-2866

Bureau of Mines
Eastern Field Operations Center
4800 Forbes Avenue
Pittsburgh, PA 15213
(412) 621-4500

U.S. Fish and Wildlife Service
Southeast Region
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3594

Office of Endangered Species
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3583

## GEORGIA

### State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Office of Surface Mining, Reclamation, and Enforcement, Region II<br>530 Gay Street, S.W., Suite 500<br>Knoxville, TN 37902<br>(615) 971-5100 |
| Fish and Wildlife | Game and Fish Division<br>Department of Natural Resources<br>270 Washington Street, Southwest<br>Atlanta, GA 30334<br>(404) 656-3530 |
| Heritage and Conservation | Georgia Natural Areas Program<br>270 Washington St., Room 713<br>Atlanta, GA 30334<br>(404) 656-4993 |
| | TVA Regional Natural Heritage Project<br>Office of Natural Resources<br>Forestry Building<br>Norris, TN 37828<br>(615) 494-9800 |
| Forestry | Forestry Commission<br>Box 819<br>Macon, GA 31298<br>(912) 744-3211 |
| Extension Services (Forest Resources) | State Extension Services<br>University of Georgia<br>Athens, GA 30602<br>(404) 542-3824 |
| Water Resources Technology | Environmental Resources Center<br>205 Old Civil Engineering Building<br>Georgia Institute of Technology<br>Atlanta, GA 30332<br>(404) 894-2375 |
| Road Construction and Maintenance | Department of Transportation<br>#2 Capitol Square<br>Atlanta, GA 30334<br>(404) 656-5206 |

## Federal Agencies

Department of Agriculture

U.S. Forest Service
Southern Region
1720 Peachtree Road, N.W., Suite 800
Atlanta, GA 30367
(404) 881-4191

Soil Conservation Service
P.O. Box 832
Athens, GA 30603
(404) 546-2274

Americus Plant Materials Center
P.O. Box 688
Americus, GA 31709
(912) 924-2286

Department of the Army

U.S. Army Corps of Engineers
South Atlantic Division
510 Title Building
30 Pryor Street, Southwest
Atlanta, GA 30303
(404) 221-6711

Department of the Interior

Office of Surface Mining, Reclamation,
and Enforcement, Region II
530 Gay Street, S.W.
Suite 500
Knoxville, TN 37902
(615) 971-5100

Bureau of Land Management
Eastern States Office
350 S. Pickett Street
Alexandria, VA 22304
(703) 235-2866

Bureau of Mines
Eastern Field Operations Center
4800 Forbes Avenue
Pittsburgh, PA 15213
(412) 621-4500

U.S. Fish and Wildlife Service
Southeast Region
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3594

Office of Endangered Species
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3583

## KENTUCKY

### State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Bureau of Surface Mining, Reclamation, and Enforcement<br>Department for Natural Resources and Environmental Protection<br>6th Floor<br>Capital Plaza Tower<br>Frankfort, KY 40601<br>(502) 564-6940 |
| Fish and Wildlife | Department of Fish and Wildlife Resources<br>No. 1 Game Farm Road<br>Arnold L. Mitchell Building<br>Frankfort, KY 40601<br>(502) 564-3400 |
| Heritage and Conservation Program | Kentucky Heritage Program<br>Kentucky Nature Preserves Commission<br>407 Broadway<br>Frankfort, KY 40601<br>(502) 564-2886 |
| | TVA Regional Natural Heritage Project<br>Office of Natural Resources<br>Forestry Building<br>Norris, TN 37828<br>(625) 494-9800 |
| Forestry | Division of Forestry<br>Department for Natural Resources and Environmental Protection<br>Teton Trail<br>Frankfort, KY 40601<br>(502) 564-4496 |
| Extension (Forestry, Entomology, Wildlife) | State Extension Service<br>University of Kentucky<br>Lexington, KY 40546<br>(606) 257-2833 |
| Water Resources Technology | Water Resources Research Institute<br>167 Anderson Hall - 00461<br>University of Kentucky<br>Lexington, KY 40506<br>(606) 257-1832 |

Road Construction and Maintenance

Bureau of Highways
Department of Transportation
10th Floor
State Office Building
Frankfort, KY 40622
(502) 564-3730

## Federal Agencies

Department of Agriculture

U.S. Forest Service
Southern Region
Suite 800
1720 Peachtree Road, N.W.
Atlanta, GA 30367
(404) 881-4191

Soil Conservation Service
333 Waller Avenue
Lexington, KY 40504
(606) 233-2749

Quicksand Plant Materials Center
Quicksand, KY 41363
(606) 666-5069

Department of the Army

U.S. Army Corps of Engineers
Louisville District
P.O. Box 59
Louisville, KY 40201
(502) 582-5601

U.S. Army Corps of Engineers
Nashville District
P.O. Box 1070
Nashville, TN 37202
(615) 251-5626

Department of the Interior

Office of Surface Mining, Reclamation
and Enforcement, Region II
530 Gay Street, Southwest
Suite 500
Knoxville, TN 37902
(615) 971-5100

Bureau of Land Management
Eastern States Office
350 South Pickett Street
Alexandria, VA 22304
(703) 235-2866

Bureau of Mines
Eastern Field Operations Center
4800 Forbes Avenue
Pittsburgh, PA 15213
(412) 621-4500

U.S. Fish and Wildlife Service
Southeast Region
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3594

Office of Endangered Species
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3583

# TENNESSEE

## State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Division of Surface Mining and Land Reclamation<br>Department of Conservation<br>1720 West End Avenue - Room 501<br>Nashville, TN 37203<br>(615) 741-3042 |
| Fish and Wildlife | Wildlife Resources Agency<br>P. O. Box 40747<br>Ellington Agricultural Center<br>Nashville, TN 37204<br>(615) 741-1431 |
| Heritage and Conservation Program | Tennessee Heritage Program<br>Department of Conservation<br>2611 West End Avenue<br>Nashville, TN 37203<br>(615) 741-3852 |
| | TVA Regional Natural Heritage Project<br>Office of Natural Resources<br>Forestry Building<br>Norris, TN 37828<br>(615) 494-9800 |
| Forestry | Division of Forestry<br>Department of Conservation<br>2611 West End Avenue<br>Nashville, TN 37203<br>(615) 741-3326 |
| Extension Services (Forestry, Wildlife, Fisheries) | State Extension Services<br>University of Tennessee<br>P. O. Box 1071<br>Knoxville, TN 37901<br>(615) 974-7114 |
| Water Resources Technology | Water Resources Research Center<br>428 South Stadium Hall<br>University of Tennessee<br>Knoxville, TN 37916<br>(615) 974-2151 |
| Road Construction and Maintenance | Bureau of Highways<br>Department of Transportation<br>James K. Polk Building, Suite 700<br>Nashville, TN 37219<br>(615) 741-2021 |

## Federal Agencies

Department of Agriculture

U.S. Forest Service
Southern Region
Suite 800
1720 Peachtree Road, N.W.
Atlanta, GA 30367
(404) 881-4191

Soil Conservation Service
675 U.S. Courthouse
Nashville, TN 37203
(615) 251-5471

Department of the Army

U.S. Army Corps of Engineers
Nashville District
P.O. Box 1070
Nashville, TN 37202
(615) 251-5626

Department of the Interior

Office of Surface Mining, Reclamation
and Enforcement, Region II
530 Gay Street, Southwest
Suite 500
Knoxville, TN 37902
(615) 971-5100

Bureau of Land Management
Eastern States Office
350 South Pickett Street
Alexandria, VA 22304
(703) 235-2866

Bureau of Mines
Eastern Field Operations Center
4800 Forbes Avenue
Pittsburgh, PA 15213
(412) 621-4500

U.S. Fish and Wildlife Service
Southeast Region
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3594

Office of Endangered Species
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, GA 30303
(404) 221-3583

## VIRGINIA

### State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Division of Mined Land Reclamation<br>P.O. Drawer U<br>Big Stone Gap, VA 24219<br>(703) 523-2925 |
| Fish and Wildlife | Commission of Game and Inland Fisheries<br>4010 W. Broad Street<br>Box 11104<br>Richmond, VA 23230<br>(804) 257-1000 |
| Heritage and Conservation Program | Virginia Natural Diversity Information Program<br>Nature Conservancy<br>Biology Department - Herbarium<br>VPI and SU<br>Blacksburg, VA 24061<br>(703) 961-5746 |
| | TVA Regional Natural Heritage Project<br>Office of Natural Resources<br>Forestry Building<br>Norris, Tennessee 37828<br>(615) 494-9800 |
| Forestry | Division of Forestry<br>Box 3758<br>Charlottesville, VA 22903<br>(804) 977-6555 |
| Extension Services (Forestry, Wildlife, Fisheries) | State Extension Services<br>Virginia Polytechnic Institute and State University<br>Blacksburg, VA 24061<br>(703) 961-6705 |
| Water Resources Technology | Virginia Water Resources Research Center<br>Virginia Polytechnic Institute and State University<br>617 N. Main Street<br>Blacksburg, VA 24060<br>(703) 961-5624 |
| Road Construction and Maintenance | Construction Division; Maintenance Division<br>Department of Highways and Transportation<br>1221 E. Broad Street<br>Richmond, VA 23219<br>(804) 786-2945; (804) 786-2847 |

## Federal Agencies

| | |
|---|---|
| Department of Agriculture | U.S. Forest Service<br>Southern Region<br>Suite 800<br>1720 Peachtree Road, N.W.<br>Atlanta, GA 30367<br>(404) 881-4191 |
| | Soil Conservation Service<br>P.O. Box 10026<br>Richmond, VA 23240<br>(804) 771-2457 |
| Department of the Army | U.S. Army Corps of Engineers<br>Huntington District<br>P.O. Box 2127<br>Huntington, WV 25721<br>(304) 529-5253 |
| | U.S. Army Corps of Engineers<br>Nashville District<br>P.O. Box 1070<br>Nashville, TN 37202<br>(615) 251-5625 |
| Department of the Interior | Office of Surface Mining, Reclamation and Enforcement, Region I<br>603 Morris St.<br>Charleston, WV 25301<br>(304) 342-8125 |
| | Bureau of Land Management<br>Eastern States Office<br>350 S. Pickett Street<br>Alexandria, VA 22304<br>(703) 235-2866 |
| | Bureau of Mines<br>Eastern Field Operations Center<br>4800 Forbes Avenue<br>Pittsburgh, PA 15213<br>(412) 612-4500 |
| | U.S. Fish and Wildlife Service<br>Region 5<br>One Gateway Center, Suite 700<br>Newton Corner, MA 02158<br>(617) 965-5100 |

Office of Endangered Species
U.S. Fish and Wildlife Service
One Gateway Center, Suite 700
Newton Corner, MA 02158
(617) 965-5100

## WEST VIRGINIA

### State Agencies and/or Programs

| | |
|---|---|
| Surface Mining Regulatory Authority | Division of Reclamation<br>Department of Natural Resources<br>1800 Washington Street, East<br>Charleston, WV 25305<br>(304) 348-3267 |
| Fish and Wildlife | Wildlife Resources Division<br>Department of Natural Resources<br>1800 Washington Street, East<br>Charleston, WV 25305<br>(304) 348-2771 |
| Heritage and Conservation Program | West Virginia Natural Heritage Program<br>Department of Natural Resources<br>Operations Center<br>219-250 South Ward Rd.<br>P.O. Box 67<br>Elkins, VA 26241<br>(304) 636-1767 |
| Forestry | Division of Forestry<br>Department of Natural Resources<br>1800 Washington Street, East<br>Charleston, WV 25305<br>(304) 348-2788 |
| Extension Services (Forest Management, Forestry, Outdoor Recreation, Environmental Education) | Center for Extension and Continuing Education<br>817 Knapp Hall<br>West Virginia University<br>Morgantown, WV 26506<br>(304) 293-5691 |
| Water Resources Technology | Water Research Institute<br>204 Knapp Hall<br>West Virginia University<br>Morgantown, WV 26506<br>(304) 293-2757 |
| Road Construction and Maintenance | Construction Division; Maintenance Division<br>Department of Highways<br>Building 5A<br>1900 E. Washington Street<br>Charleston, WV 25305<br>(304) 348-2871; (304) 348-2901 |

Federal Agencies

Department of Agriculture

U.S. Forest Service, Eastern Region
Clark Building
633 W. Wisconsin Avenue
Milwaukee, WI 53203
(414) 291-3693

Soil Conservation Service
75 High Street, Room 301
Morgantown, WV 26505
(304) 599-7151

Department of the Army

U.S. Army Corps of Engineers
Huntington District
P.O. Box 2127
Huntington, WV 25721
(304) 529-5253

U.S. Army Corps of Engineers
Pittsburgh District
Federal Building
1000 Liberty Avenue
Pittsburgh, PA 15222
(412) 644-6800

Department of the Interior

Office of Surface Mining, Reclamation and Enforcement, Region I
603 Morris St.
Charleston, WV 25301
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# APPENDIX B

## B.1 LIST OF COMMON AND SCIENTIFIC NAMES OF PLANT SPECIES REFERENCED IN THE TEXT

| Common Name | Latin Name |
|---|---|
| | Trees - Conifers |
| Loblolly pine | *Pinus taeda* L. |
| Shortleaf pine | *Pinus echinata* Miller |
| Virginia pine | *Pinus virginiana* Miller |
| | Trees - Hardwoods |
| Basswood | *Tilia* spp. |
| Beech | *Fagus grandifolia* Ehrhart |
| Black gum | *Nyssa sylvatica* Marshall |
| Black locust | *Robinia pseudo-acacia* L. |
| Black oak | *Quercus velutina* Lam. |
| Buckeye | *Aesculus octandra* Marshall. |
| Chestnut oak | *Quercus prinus* L. |
| Dogwood | *Cornus florida* L. |
| Green ash | *Fraxinus pennsylvanica* Marshall |
| Mockernut hickory | *Carya tomentosa* (Poiret) Nuttall |
| Northern red oak | *Quercus rubra* L. |
| Pignut hickory | *Carya glabra* (Miller) Sweet |
| Post oak | *Quercus stellata* Wang. |
| Scarlet oak | *Quercus coccinea* Meunchh. |
| Sugar maple | *Acer saccharum* Marsh. |
| Sourwood | *Oxydendrum arboreum* (L.) DC. |
| Southern red oak | *Quercus falcata* Michaux |
| Sweet birch | *Betula lenta* L. |
| Toringo crabapple | *Malus sieboldi* |
| Tulip poplar | *Liriodendron tulipifera* L. |
| White oak | *Quercus alba* L. |
| Yellow birch | *Betula lutea* Michaux f. |

B.1 (Continued)

| Common Name | Latin Name |
|---|---|
| | Shrubs - Vines |
| Autumn olive | Elaeagnus umbellata Thunberg. |
| Bayberry | Myrica pennsylvanica Loisel. |
| Indigobush, False indigo | Amorpha fruticosa L. |
| Multiflora rose | Rosa multiflora Thunberg. |
| Northern bayberry | Myrica pennsylvanica Loisel. |
| Purple-osier willow | Salix purpurea |
| Silky dogwood | Cornus amomum Miller. |
| Sumac | Rhus spp. |
| Tatarian honeysuckle | Lonicera tatarica L. |
| Viburnum | Viburnum spp. |
| | Herbs - Leguminous Forbs |
| Bicolor lespedeza | Lespedeza bicolor Turcy. |
| Birdsfoot trefoil | Lotus corniculatus L. |
| Sericea lespedeza | Lespedeza cuneata (Dumont) G. Don |
| Cowpea | Vigna sinensis Endl. |
| Kobe lespedeza | Lespedeza striata (Thunberg) H. & A. |
| Korean lespedeza | Lespedeza stipulacea Maxim. |
| Red clover | Trifolium pratense L. |
| Soybean | Glycine max (L.) Merrill |
| Sweet clover | Melilotus spp. |
| Vetch | Vicia spp. |
| White clover | Trifolium repens L. |
| | Herbs - Nonleguminous Forbs |
| Buckwheat | Fagopyrum spp. |
| Sunflower | Helianthus annuus L. |
| | Grasses |
| Annual ryegrass | Lolium multiflorum Lam. |
| Balbo rye | Elymus sp. |
| Bluestem, big | Andropogon gerardii Vitm. |
| Bluestem, little | Andropogon scoparius L. |
| Field bromegrass | Bromus japonicus Thunberg. |
| Foxtail (German) millet | Setaria italica (L.) Beauvois |
| Grain sorghum | Sorghum bicolor (L.) Moench |
| Indiangrass | Sorghastrum mutans (L.) Nash. |
| Japanese millet | Echinochloa spp. |
| Kafir | Sorghum vulgare var. caffrorum (Retz.) Hubb. and Rehder |

**B.1 (Concluded)**

| Common Name | Latin Name |
|---|---|
| 'Ky-31' tall fescue | *Festuca arundinacea* Schreb. 'K-31' |
| Oats | *Avena sativa* L. |
| Orchard grass | *Dactylis glomerata* L. |
| Pearl millet | *Pennisetum glaucum* (L.) R. Br. |
| Perennial ryegrass | *Lolium perenne* L. |
| Proso millet | *Panicum miliaceum* L. |
| Redtop | *Agrostis alba* L. |
| Rye | *Secale cereale* L. |
| Sudangrass | *Sorghum sudanense* (Piper) Stapf |
| Switchgrass | *Panicum virgatum* L. |
| Timothy | *Phleum pratense* L. |
| Weeping lovegrass | *Eragrostis curvula* (Shrad.) Nees |
| Wheat | *Triticum aestivum* L. |
| Winter wheat | *Triticum* spp. |
| Winter rye | *Secale cereale* L. |

## B.2 LIST OF COMMON AND SCIENTIFIC NAMES OF ANIMAL SPECIES REFERENCED IN THE TEXT

| Common Name | Latin Name |
|---|---|
| **Birds** | |
| American coot | *Fulica americana* |
| Barn owl | *Tyto alba* |
| Blue-winged teal | *Anas discors* |
| Bobwhite quail | *Colinus virginianus* |
| Cardinal | *Cardinalis cardinalis* |
| Carolina chickadee | *Parus carolinensis* |
| Carolina wren | *Thryothorus ludovicianus* |
| Canada goose | *Branta canadensis* |
| Crested flycatcher (Great) | *Myiarchus crinitus* |
| Downy woodpecker | *Picoides pubescens* |
| Eastern bluebird | *Sialia sialis* |
| House wren | *Troglodytes aedon* |
| Kestrel (American) | *Falco sparverius* |
| Killdeer | *Charadrius vociferous* |
| Lesser scaup | *Athya affinis* |
| Mallard | *Anas platyrhynchos* |
| Meadowlark (Eastern) | *Sturnella magna* |
| Mockingbird (Northern) | *Mimus polyglottos* |
| Mourning dove | *Zenaida macroura* |
| Pheasant (Ring-necked) | *Phasianus colchicus* |
| Pied-billed grebe | *Podilymbus podiceps* |
| Pintail (Common) | *Anas acuta* |
| Purple martin | *Progne subis* |
| Red-bellied woodpecker | *Melanerpes carolinus* |
| Redhead | *Athya americana* |
| Red-headed woodpecker | *Melanerpes erythrocephalus* |
| Ruffed grouse | *Benasa umbellus* |
| Screech owl (Common) | *Otus asio* |
| Shoveler (Northern) | *Anas clypeata* |
| Thrasher (Brown) | *Toxostoma rufum* |
| Towhee (Rufous-sided) | *Pipilo erythrophthalmus* |
| Tree swallow | *Iridoprocne bicolor* |
| Tufted titmouse | *Parus bicolor* |
| White-breasted nuthatch | *Sitta carolinensis* |
| Wild turkey | *Meleagris gallopavo* |
| Woodcock (American) | *Philohela minor* |
| Wood duck | *Aix sponsa* |
| Yellow-bellied sapsucker | *Sphyrapicus varius* |
| Yellow-shafted flicker (Common) | *Colaptes auratus* |

## B.2 (Concluded)

| Common Name | Latin Name |
|---|---|
| | **Fish** |
| Bluegill | *Lepomis macrochirus* |
| Catfish (bullhead) | *Ictalurus* spp. |
| Catfish (channel) | *Ictalurus punctatus* |
| Crappie | *Pomoxis* spp. |
| Israeli carp | *Cyprinus* sp. |
| Largemouth bass | *Micropterus salmoides* |
| Redear sunfish | *Lepomis microlophus* |
| Trout (brook) | *Salvelinus fontinalis* |
| Trout (rainbow) | *Salmo gairdneri* |
| | **Mammals** |
| Bear (black) | *Ursus americanus* |
| Beaver | *Castor canadensis* |
| Bobcat | *Lynx rufus* |
| Gray fox | *Urocyon cinereoargenteus* |
| Gray squirrel (eastern) | *Sciurus carolinensis* |
| Mule deer | *Odocoileus hemionus* |
| Oppossum | *Didelphis marsupialis* |
| Rabbit (cottontail) | *Sylvilagus floridanus* |
| Raccoon | *Procyon lotor* |
| Red fox | *Vulpes fulva* |
| Skunk (striped) | *Mephitis mephitis* |
| White-tailed deer | *Odocoileus virginianus* |
| Wild pig (boar) | *Sus scrofa* |
| Woodchuck | *Marmota monax* |

# APPENDIX C

## LIST OF PLANT SPECIES AND THEIR USES FOR WILDLIFE IN THE CENTRAL AND SOUTHERN APPALACHIAN REGION

| | Uses[a] | | | | | |
|---|---|---|---|---|---|---|
| Plant Name | Browse | Cover | Fruit | Herbage Foliage | Mast | Seeds |
| **Trees:** | | | | | | |
| Ashes - *Fraxinus* spp. | 2 | | | | | 1 |
| Birches - *Betula* spp. | 1 | 3 | | | | 2 |
| Black locust - *Robinia pseudoacacia* | 3 | 2 | | | | 1 |
| Black walnut - *Juglans nigra* | | | | | 1 | |
| Chinese chestnut - *Castanea mollissima* | 2 | | | | 1 | |
| Crabapples - *Malus* spp. | 3 | 2 | 1 | | | |
| Eastern redcedar - *Juniperus virginiana* | 3 | 1 | 2 | | | |
| European black alder - *Alnus glutinosa* | 3 | 1 | | | | 2 |
| Flowering dogwood - *Cornus florida* | 2 | 3 | 1 | | | |
| Maples - *Acer* spp. | 2 | | | | | 1 |
| Oaks - *Quercus* spp. | 2 | 3 | | | 1 | |
| Pines - *Pinus* spp. | 3 | 1 | | | | 2 |
| Russian olive - *Elaeagnus angustifolia* | | 2 | 1 | | | |
| Sassafras - *Sassafras albidum* | 1 | 3 | 2 | | | 4 |
| Spruces - *Picea* spp. | 3 | 1 | | | | 2 |
| Sycamore - *Platanus occidentalis* | 2 | | | | | 1 |
| Sweetgum - *Liquidambar styraciflua* | | 2 | | | | 1 |
| Tulip poplar - *Liriodendron tulipifera* | 2 | | | | | 1 |
| **Shrubs:** | | | | | | |
| Amur privet - *Ligustrum amurense* | | 2 | 1 | | | |
| Autumn olive - *Elaeagnus umbellata* | 2 | 3 | 1 | | | |
| Bayberry - *Myrica pennsylvanica* | 3 | 2 | 1 | | | |
| Bicolor lespedeza - *Lespedeza bicolor* | | 3 | | 2 | | 1 |
| Bristly locust - *Robinia fertilis* | | 1 | | | | 2 |
| Bush honeysuckle - *Lonicera* spp. | 2 | 3 | 1 | | | |
| Coralberry - *Symphoricarpos orbiculatus* | 2 | 3 | 1 | | | |
| Cranberrybush, arrowwood - *Viburnum* spp. | 2 | 3 | 1 | | | |
| Dogwoods - *Cornus* spp. | 2 | 3 | 1 | | | |
| Hawthorns - *Crataegus* spp. | 3 | 1 | 2 | | | |
| Indigobush - *Amorpha fruticosa* | 2 | 1 | | | | 3 |
| Japanese honeysuckle - *Lonicera japonica* | 2 | 1 | 3 | | | |
| Rose - *Rosa* spp. | 3 | 1 | 2 | | | 4 |
| Sumacs - *Rhus* spp. | 2 | 3 | 1 | | | |
| **Herbs (Grasses):** | | | | | | |
| Bermuda grass - *Cynodon dactylon* | | | | 1 | | 2 |
| Bluestems - *Andropogon* spp. | | 1 | | 2 | | 3 |
| Deertongue - *Panicum clandestinum* | | 3 | | 1 | | 2 |
| Foxtail millet - *Setaria italica* | | | | | | 1 |
| Indiangrass - *Sorghastrum nutans* | | 1 | | 2 | | 3 |
| Japanese millet - *Echinochloa* spp. | | | | | | 1 |

## APPENDIX C (Concluded)

| Plant Name | Uses[a]<br>Browse | Cover | Fruit | Herbage Foliage | Mast | Seeds |
|---|---|---|---|---|---|---|
| Ky-31 tall fescue - *Festuca arundinacea* var. *'K-31'* | | 3 | | 1 | | 2 |
| Oats - *Avena sativa* | | | | 2 | | 1 |
| Orchardgrass - *Dactylis glomerata* | | 3 | | 1 | | 2 |
| Pearl millet - *Pennisetum glaucum* | | | | | | 1 |
| Proso millet - *Panicum milaceum* | | | | | | 1 |
| Redtop - *Agrostis alba* | | 1 | | 2 | | 3 |
| Reed canarygrass - *Phalaris arundinacea* | | 2 | | | | 1 |
| Rye - *Secale cereale* | | | | 2 | | 1 |
| Ryegrass - *Lolium* spp. | | | | 1 | | 2 |
| Sorghums - *Sorghum* spp. | | | | | | 1 |
| Switchgrass - *Panicum virgatum* | | 1 | | 3 | | 2 |
| Timothy - *Phleum pratense* | | | | 2 | | 1 |
| Weeping lovegrass - *Eragrostis curvula* | | 1 | | 2 | | 3 |
| Wheat - *Triticum aestivum* | | | | 2 | | 1 |
| *Herbs (Leguminous Forbs)*: | | | | | | |
| Alfalfa - *Medicago sativa* | | 3 | | 1 | | 2 |
| Annual lespedeza - *Lespedeza* spp. | | | | | | 1 |
| Birdsfoot trefoil - *Lotus corniculatus* | | 2 | | 1 | | |
| Clovers - *Trifolium* spp. | | | | 1 | | 2 |
| Cowpea - *Vigna sinensis* | | | | 2 | | 1 |
| Crownvetch - *Coronilla varia* | | 1 | | 2 | | |
| Flatpea - *Lathyrus sylvestris* | | 1 | | 2 | | 3 |
| Hairy vetch - *Vicia villosa* | | 3 | | 1 | | 2 |
| Partridge pea - *Cassia fasciculata* | | | | | | 1 |
| Sericea lespedeza - *Lespedeza cuneata* | | 1 | | 3 | | 2 |
| Soybean - *Glycine max* | | | | 2 | | 1 |
| Sweet clover - *Melilotus* spp. | | | | 2 | | 1 |
| *Herbs (Non-Leguminous Forbs)*: | | | | | | |
| Buckwheat - *Fagopyrum* spp. | | | | 2 | | 1 |
| Sunflower - *Helianthus annuus* | | | | | | 1 |

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[a] Uses adapted from Rafaill and Vogel (1978) and McAtee (1936). For each species, the use is rated from most important (1) to least (3) within the uses shown. Importance will vary between species of wildlife.

Rafaill, B. L.; Vogel, W. G. A guide for vegetating surface-mined lands for wildlife in eastern Kentucky and West Virginia. U.S. Fish and Wildlife Service. FWS/OBS-78/84; July 1978.

McAtee, W. L. Groups of plants valuable for wildlife utilization and erosion control. Washington, D.C. USDA Circ. No. 412. 1936.

50272-101

| | | | |
|---|---|---|---|
| **REPORT DOCUMENTATION PAGE** | 1. REPORT NO.<br>FWS/OBS-83/08 | 2. | 3. Recipient's Accession No. |

4. Title and Subtitle
Practices for protecting and enhancing fish and wildlife on coal surface-mined land in the Central and Southern Appalachia region.

5. Report Date
March 1983

6.

7. Author(s) Richard E. Ambrose, Charles R. Hinkle, Calvin R. Wenzel

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Science Applications, Inc.
800 Oak Ridge Turnpike
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10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) 14-16-0009-80-075
(G)

12. Sponsoring Organization Name and Address

Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
Washington, DC 20240

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This handbook contains information on the best current pratices to minimize disturbances and adverse impacts of surface mining on fish and wildlife resources. Current state and federal legislation was reviewed to determine those practices which were most compatible with the best technology currently available, fish and wildlife plans, and reclamation plans for the Central and Southern Appalachia region of the U.S. The information presented includes risks, limitations, approximate costs, and maintenance and management requirements of each practice. Plans for the restoration of specific habitats, according to the best current practices, are also included.

17. Document Analysis a. Descriptors

Surface mining
Coal mining
Reclamation
Wildlife
Fishes

b. Identifiers/Open-Ended Terms

Appalachia
Revegetation
Wildlife management
Mitigation
Habitat improvement
West Virgina
Tennessee
Kentucky
Alabama
Mississippi

c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report)

21. No. of Pages
208

20. Security Class (This Page)

22. Price

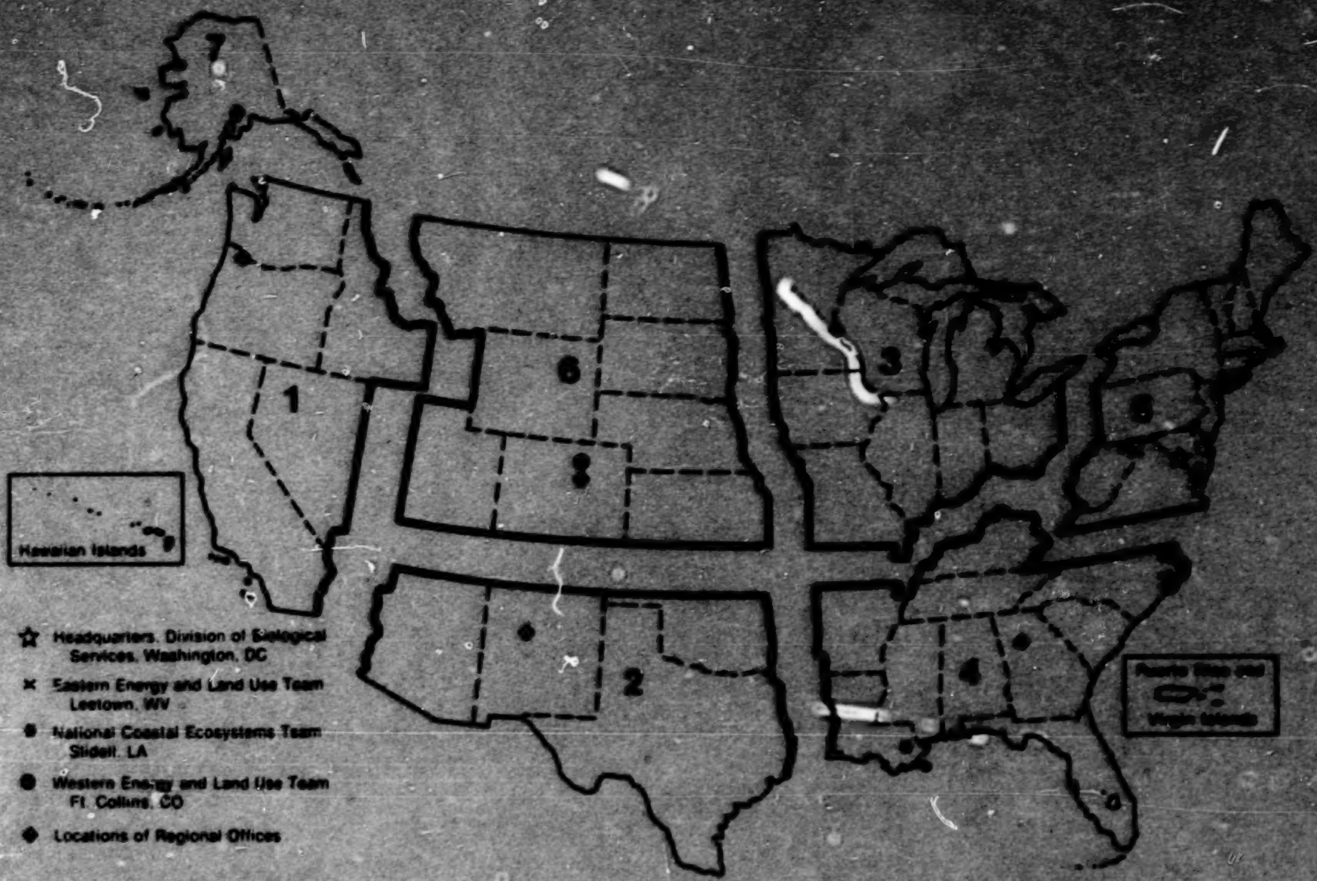
(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

207

☆ U.S. Government Printing Office 1983 - 679-761/326 Reg. 8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Puerto Rico and Virgin Islands
☆ Headquarters, Division of Biological Services, Washington, DC
× Eastern Energy and Land Use Team Leetown, WV
● National Coastal Ecosystems Team Slidell, LA
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